Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, November 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

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Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes per gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 1 gives the 95 percent confidence limits between which the true concentrations of the selected radionuclides might be expected in the analyses. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

[2] The conversion factor is 1.18×10^{-9} g K/pc K^{40}.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for November 1964 (November 1-28). Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, tables 3 and 4 have been prepared from the monthly averages shown in table 2, and November 1963 data has been included for comparison.

The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. The data regarding reported nuclear detonations given in this figure are presented for information only. The underground nuclear detonations during 1963 and 1964 are not intended to imply a cause and effect relationship with the rising strontium levels during this period.

Each graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, NOVEMBER 1964

Sampling locations		Calcium (g/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)		Barium-140 (pc/liter)	
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month
Ala:	Montgomery	1.17	1.20	<5	<5	21	20	65	60	0	0	0	0
Alaska:	Palmer	1.17	1.27	<5	<5	16	19	105	80	0	0	0	0
Ariz:	Phoenix	1.15	1.20	<5	<5	3	4	25	20	0	0	0	0
Ark:	Little Rock	1.15	1.18	<5	<5	38	33	80	60	0	0	0	0
Calif:	Sacramento	1.26	1.31	<5	<5	6	6	30	30	0	0	0	0
	San Francisco	1.22	1.23	<5	<5	7	4	35	35	0	0	0	0
C. Z:	Cristobal	1.11	1.14	<5	<5	5	5	50	50	0	0	0	0
Colo:	Denver	1.25	1.24	<5	<5	20	16	100	60	0	0	0	0
Conn:	Hartford	1.10	1.16	<5	<5	19	14	110	90	0	0	0	0
Del:	Wilmington	1.15	1.19	<5	<5	20	16	85	70	0	10	0	0
D. C:	Washington	1.11	1.14	<5	<5	19	17	65	40	0	0	0	0
Fla:	Tampa	1.19	1.19	<5	<5	17	14	255	210	0	0	0	0
Ga:	Atlanta	1.17	1.19	<5	<5	28	25	105	90	0	0	0	0
Hawaii:	Honolulu	1.19	1.20	<5	5	11	15	70	70	0	0	0	0
Idaho:	Idaho Falls	1.24	1.24	<5	<5	25	21	110	85	0	0	0	0
Ill:	Chicago	1.14	1.20	<5	<5	19	16	85	70	0	0	0	0
Ind:	Indianapolis	1.15	1.22	<5	<5	18	15	70	60	0	10	0	0
Iowa:	Des Moines	1.21	1.23	<5	<5	22	23	70	50	0	0	0	0
Kans:	Wichita	1.17	1.27	<5	<5	18	19	50	30	0	0	0	0
Ky:	Louisville	1.13	1.19	<5	<5	27	24	50	45	0	0	0	0
La:	New Orleans	1.19	1.23	<5	15	48	40	115	70	0	0	0	0
Maine:	Portland	1.14	1.23	<5	<5	29	26	175	155	0	10	0	0
Md:	Baltimore	1.13	1.17	<5	<5	21	19	70	50	0	0	0	0
Mass:	Boston	1.13	1.17	<5	<5	31	23	180	130	0	0	0	0
Mich:	Detroit	1.14	1.19	<5	<5	16	16	90	75	0	10	0	0
	Grand Rapids	1.15	1.23	<5	<5	19	20	100	90	0	10	0	0
Minn:	Minneapolis	1.21	1.24	<5	5	27	23	115	75	0	0	0	0
Miss:	Jackson	1.21	1.23	<5	5	37	30	85	60	0	0	0	0
Mo:	Kansas City	1.19	1.22	<5	<5	26	21	55	40	0	0	0	0
	St. Louis	1.20	1.24	<5	<5	21	18	55	40	0	0	0	0
Mont:	Helena	1.20	1.26	<5	<5	20	15	115	85	0	0	0	0
Nebr:	Omaha	1.21	1.13	<5	<5	24	18	70	40	0	0	0	0
Nev:	Las Vegas	1.19	1.25	<5	<5	6	10	50	55	0	0	0	0
N. H:	Manchester	1.17	1.18	<5	<5	30	22	205	165	0	10	0	10
N. J:	Trenton	1.12	1.14	<5	<5	18	17	85	70	0	10	0	0
N. Mex:	Albuquerque	1.19	1.24	<5	<5	9	9	45	45	0	0	0	0
N. Y:	Buffalo	1.09	1.14	<5	<5	18	16	105	90	0	0	0	0
	New York	1.09	1.20	<5	<5	25	22	120	95	0	10	0	10
	Syracuse	1.12	1.14	<5	<5	15	16	80	90	0	0	0	0
N. C:	Charlotte	1.17	1.21	<5	<5	38	30	100	65	0	0	0	0
N. Dak:	Minot	1.22	1.23	10	<5	49	35	145	100	0	0	0	0
Ohio:	Cincinnati	1.17	1.19	<5	<5	19	19	60	60	0	0	0	0
	Cleveland	1.12	1.18	<5	5	19	18	90	70	0	0	0	0
Okla:	Oklahoma City	1.12	1.18	<5	10	19	18	50	45	0	0	0	0
Ore:	Portland	1.24	1.30	<5	<5	30	23	165	85	0	0	0	0
Pa:	Philadelphia	1.11	1.20	<5	<5	18	16	80	60	0	0	0	0
	Pittsburgh	1.14	1.19	<5	<5	29	25	120	80	0	0	0	10
P. R:	San Juan	1.15	1.14	<5	<5	12	10	70	50	0	0	0	0
R. I:	Providence	1.13	1.18	<5	<5	23	18	140	95	0	0	0	10
S. C:	Charleston	1.15	1.18	<5	<5	31	28	110	90	0	0	0	0
S. Dak:	Rapid City	1.19	1.10	<5	<5	43	32	125	110	0	0	0	0
Tenn:	Chattanooga	1.20	1.20	<5	10	39	31	90	65	0	0	0	0
	Memphis	1.16	1.19	<5	<5	28	23	55	40	0	0	0	0
Tex:	Austin	1.11	1.17	<5	<5	7	8	35	25	0	0	0	0
	Dallas	1.14	1.18	<5	<5	17	15	45	30	0	0	0	0
Utah:	Salt Lake City	1.27	1.34	<5	<5	25	14	165	65	0	0	0	0
Vt:	Burlington	1.13	1.20	<5	<5	25	23	140	110	0	10	0	0
Va:	Norfolk	1.13	1.20	<5	5	23	19	75	55	0	0	0	0
Wash:	Seattle	1.23	1.24	5	5	28	24	170	90	0	0	0	0
	Spokane	1.22	1.31	<5	<5	26	21	130	95	0	0	0	0
W. Va:	Charleston	1.13	1.16	<5	<5	24	17	50	40	0	0	0	0
Wis:	Milwaukee	1.19	1.24	<5	<5	14	15	95	80	0	10	0	0
Wyo:	Laramie	1.18	1.22	<5	<5	20	15	105	75	0	0	0	0
Network average		1.17	1.21	<5	<5	22.3	19.1	94	72	0	<10	0	<10

year. The last column in table 2 shows the most recent issue in which a graph of the strontium-90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960-March 1964 in the July 1964 issue of *RHD* (*2*).

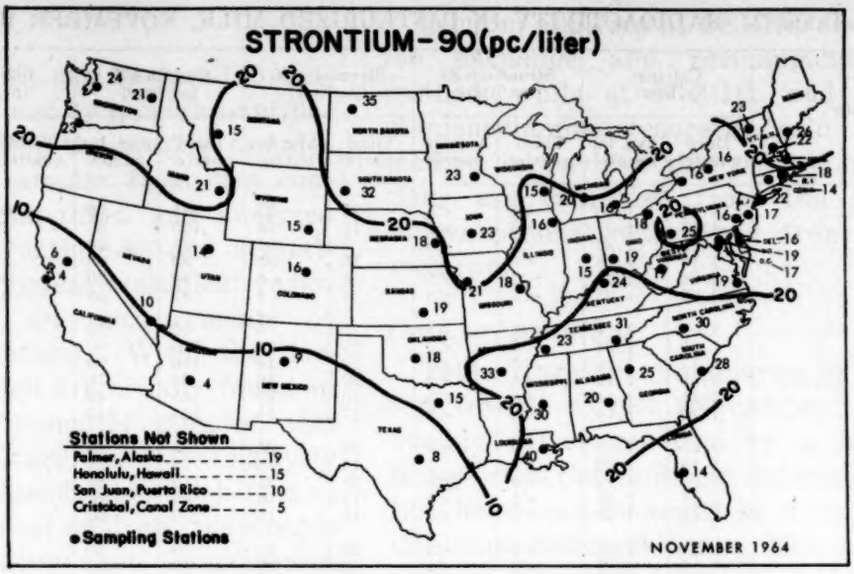

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, NOVEMBER 1964

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES FOR STRONTIUM-90, JUNE–NOVEMBER 1964 AND NOVEMBER 1963

Range (pc/liter)	Number of stations in range						
	1964						1963
	June	July	Aug.	Sept.	Oct.	Nov.	Nov.
Under 10	4	6	7	8	6	6	6
10–19	6	6	23	27	37	31	9
20–29	23	29	23	20	13	19	31
30–39	17	14	6	6	7	6	13
40–49	10	4	4	2	0	1	3
50–59	2	1	0	0	0	0	1
60–69	0	2	0	0	0	0	0
70–79	1	0	0	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, JUNE–NOVEMBER 1964 AND NOVEMBER 1963

Range (pc/liter)	Number of stations in range						
	1964						1963
	June	July	Aug.	Sept.	Oct.	Nov.	Nov.
Under 50	1	4	6	14	16	15	2
50–99	19	24	30	33	40	41	21
100–149	24	21	19	13	6	4	22
150–199	13	8	6	2	0	2	10
200–249	4	3	1	1	1	1	5
250–299	2	2	1	0	0	0	3

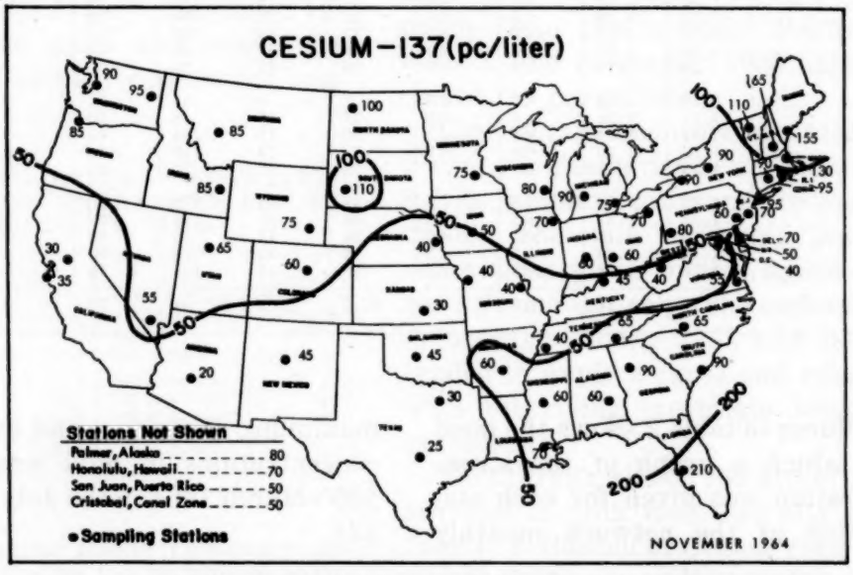

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, NOVEMBER 1964

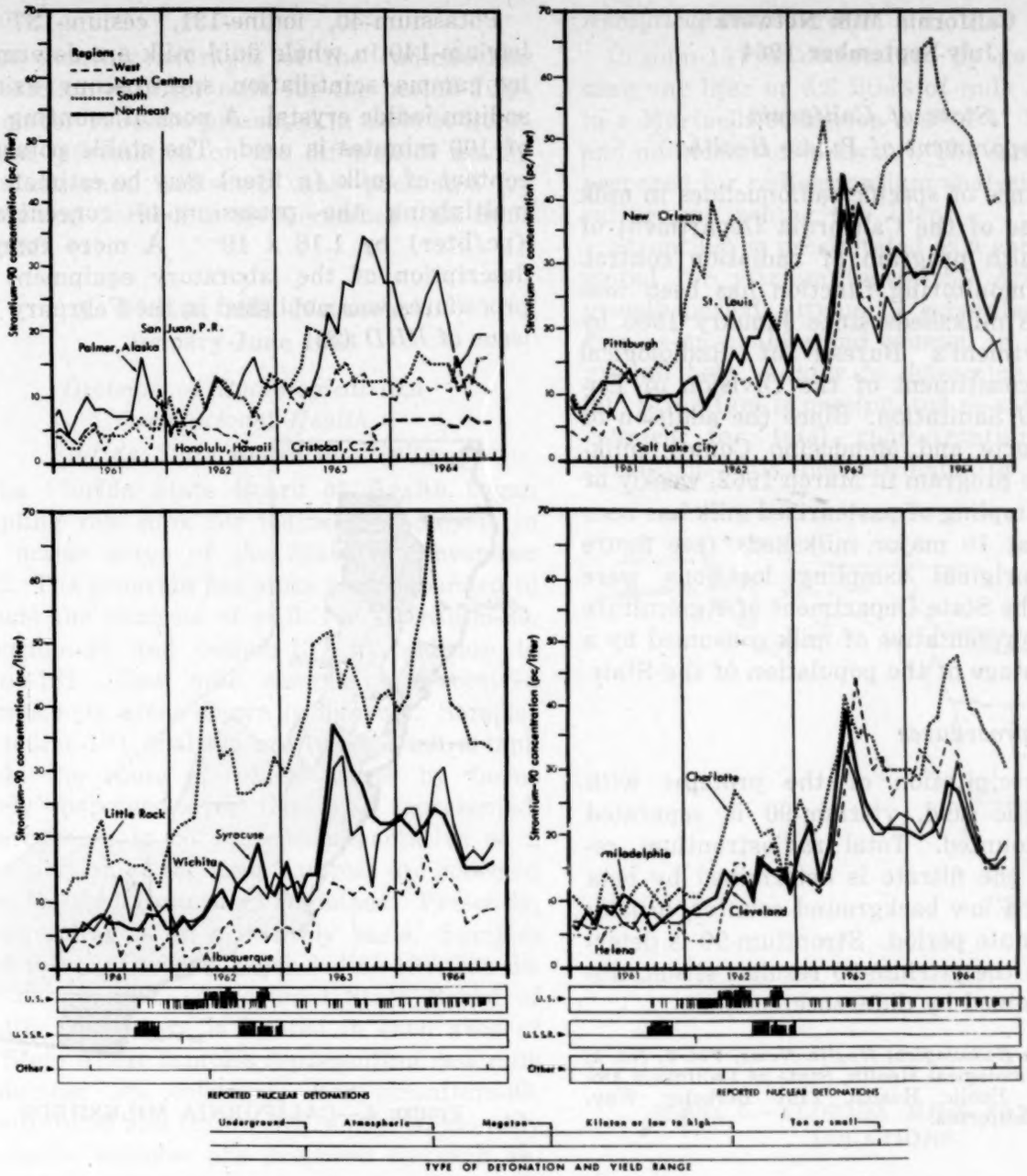

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–NOVEMBER 1964

2. California Milk Network[3], July-September 1964

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino County milksheds to the program in March 1962, weekly or biweekly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

Analytical procedures

After precipitation of the proteins with trichloroacetic acid, yttrium-90 is separated and beta counted. Total radiostrontium remaining in the filtrate is determined by beta counting in a low background counter, usually for a 60-minute period. Strontium-90 is determined from the yttrium-90 results; strontium-89 is determined by difference.

Potassium-40, iodine-131, cesium-137 and barium-140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium-iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium-40 concentration (pc/liter) by 1.18×10^{-3}. A more complete description of the laboratory equipment and procedures was published in the February 1963 issue of *RHD* (*3*).

FIGURE 4.—CALIFORNIA MILKSHEDS

[3] Data from *Radiological Health News, Vol. 3*, No. 4, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

TABLE 5.—RADIONUCLIDES IN CALIFORNIA MILK,[a] JULY-SEPTEMBER 1964

[Radioactivity concentrations in pc/liter]

Element and month		Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)	July	1.25	1.20	1.24	1.20	1.15	1.18	1.10	1.20	1.05	1.20	1.18
	Aug	1.33	1.10	1.14	1.00	1.20	1.10	1.10	1.10	1.10	1.20	1.14
	Sept	1.30	1.20	1.28	0.96	1.20	1.20	1.20	1.20	1.20	1.20	1.19
Potassium-40	July	1,460	1,200	1,170	1,210	1,230	1,170	1,250	1,190	1,240	1,220	1,234
	Aug	1,220	1,210	1,140	1,230	1,190	1,170	1,270	1,320	1,180	1,280	1,221
	Sept	1,010	1,190	1,070	1,200	1,210	1,210	1,230	1,180	1,240	1,210	1,175
Strontium-89	July	14	[b]	2	[b]	[b]	[b]	[b]	[b]	[b]	[b]	2
	Aug	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
	Sept	[b]	[b]	9	[b]	[b]	[b]	[b]	[b]	[b]	[b]	1
Strontium-90	July	54	3.9	14	3.8	6.4	11.0	4.3	4.9	12.1	6.1	12.0
	Aug	56	4.0	11	6.2	7.4	4.5	3.3	3.9	7.3	4.0	10.8
	Sept	32	4.2	13	3.7	6.0	5.7	3.1	6.5	5.6	5.2	8.5
Cesium-137	July	155	26	40	23	31	25	15	34	44	34	43
	Aug	110	18	27	16	28	26	13	20	41	27	33
	Sept	54	18	18	14	18	21	11	24	25	18	22

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
[b] No detectable activity.

Results

The monthly averages of the radionuclide and calcium data for milk for the period July-September 1964 are presented in table 5. Background information on the differences among the California milksheds was presented by Heslep and Cornish in the December 1963 issue of *RHD* (*4*).

3. Florida Milk Network, January-June 1964

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium-89, strontium-90 and cesium-137 in addition to iodine-131. Raw milk samples are received from the six areas shown in figure 5. Samples for iodine-131 analysis are taken from a tank truck, the route of which passes by farms widely dispersed over the area represented. Where there is no route representative of a large portion of the area, samples are collected from selected farms and combined. Presently, the sampling is on a monthly basis. Samples were collected weekly when iodine-131 was detectable in milk. A regional State Board of Health Laboratory is located in each area of the State where samples representing raw milk production are collected. For strontium-89, strontium-90 and cesium-137 analysis, monthly composite samples are prepared by each regional laboratory from a randomly selected 10 percent of the farms which have their milk regularly sampled for bacteriological analyses by the county health departments. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms—using locally grown feeds in the "West Florida" region—to larger farms using different types of grass and predominantly purchased feeds in the southern areas.

Analytical procedures

Cesium-137 is determined by gamma scanning one liter or 3.5 liters of milk as received in a Marinelli beaker on a 4" x 4" NaI crystal and multichannel analyzer. The sample is then prepared for radiostrontium analysis by evaporating and ashing one liter.

Strontium is precipitated as a carbonate and stored for yttrium ingrowth. After the ingrowth period, yttrium is separated with carrier as an oxalate and counted in a low-background beta counter to determine strontium-90. Strontium is precipitated as carbonate and counted for total radiostrontium activity. Strontium-89 is then calculated by difference.

FIGURE 5.—FLORIDA MILK SAMPLING LOCATIONS

Results

Table 6 presents the available monthly average strontium-89 and strontium-90 concentrations in Florida raw milk during January-April 1964. Table 7 presents cesium-137 and iodine-131 results for January-June 1964. Strontium-89, strontium-90, and cesium-137 results for 1963 appeared in the October 1964 issue of *RHD* (*5*). The results for 1963 appeared in the March 1964 issue of *RHD* (*6*). A comparison of these data indicate that during the early part of 1964 Florida milk had lower strontium-89 levels but higher strontium-90 levels than were observed in the preceding 9 months.

TABLE 6.—STRONTIUM-89 AND STRONTIUM-90 IN FLORIDA RAW MILK, JANUARY–APRIL 1964

[pc/liter]

Radionuclide and month	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay	Southeast Florida	Average
Strontium-89							
January	<5	<5	<5	<5	<5	<5	<5
February	<5	<5	<5	<5	<5	<5	<5
March	<5	<5	<5	<5	<5	<5	<5
April	<5	<5	<5	<5	<5	<5	<5
May							
June							
Average	<5	<5	<5	<5	<5	<5	<5
Average (Jan-Dec 1963)	32	32	28	30	26	31	30
Strontium-90							
January	17	16	15	10	8	12	13
February	10	11	10	11	13	10	11
March	13	14	11	12	10	15	13
April	15	17	14	10	15	14	14
Average	13.8	14.5	12.5	10.8	11.5	12.8	12.8
Average (Jan-Dec 1963)	10.4	9.6	9.1	10.1	8.7	9.2	9.5

TABLE 7.—CESIUM-137 AND IODINE-131 IN FLORIDA RAW MILK, JANUARY–JUNE 1964

[pc/liter]

Radionuclide and month	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay	Southeast Florida	Average
Cesium-137							
January	191	170	159	211	176	201	185
February	192	203	196	244	198	200	206
March	232	175	181	309	234	234	228
April	213	276	278	294	250	251	260
May	305	284	287	363	264	264	295
June	256	240	182	347	261	246	255
Average	232	225	214	295	231	233	238
Average (Apr-Dec 1963)	180	183	228	227	202	218	206
Iodine-131							
January	<2	—	<2	<2	<2	<2	<2
February	<2	—	<2	<2	<2	<2	<2
March	<2	—	<2	<2	<2	<2	<2
April	<2	—	<2	<2	<2	<2	<2
May	<2	—	<2	<2	<2	<2	<2
June	<10	—	<10	<10	<10	<10	<10

4. Oregon Milk Network, June-September 1964

Division of Sanitation & Engineering
Oregon State Board of Health

The Oregon State Board of Health conducts milk monitoring at eight major milk-producing centers throughout the State of Oregon, as shown in figure 6. Half-gallon samples of pasteurized packaged milk are collected statewide on a monthly basis by the Oregon Department of Agriculture and weekly in the Portland area by the city of Portland. The sampling frequency is accelerated to a weekly schedule at those locations having radionuclide concentrations in milk in excess of 100 pc/liter for iodine-131 or 500 pc/liter for cesium-137. The samples are forwarded to the Oregon State

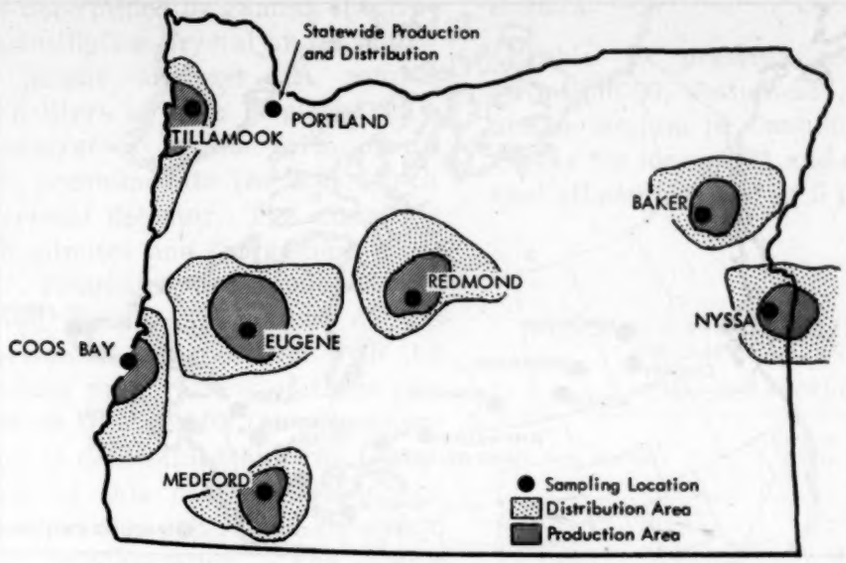

FIGURE 6.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS

Board of Health environmental radiation laboratory for iodine-131, cesium-137, barium-140, and strontium-90 analyses. The gamma analyses are performed utilizing a 3″ x 3″ sodium iodide scintillation detector with a 512-channel gamma spectrometer. Samples are normally counted for 100 minutes. The strontium-90 concentrations reported by the Oregon State Board of Health were obtained by the trichloracetic acid analytical procedure (7) with a low background beta counter equipped with a 2-inch detector used for counting. The minimum detectable concentrations for iodine-131, cesium-137, and barium-140 are 15 pc/liter. The minimum detectable concentration is defined to be that amount of activity which, in the same counting time, gives a count that differs from the background count by 3 times the standard deviation (σ) of the background count.

Table 8 presents the Oregon milk surveillance data for the period June through September 1964. The Portland composite sample represents contributions from nearly all milksheds in Oregon, plus some in southern Washington. Thus, it tends to represent a State average.

TABLE 8.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, JUNE-SEPTEMBER 1964 [a]

[Average concentrations in pc/liter]

Sampling location and frequency	Nuclide	June	July	Aug.	Sept.
Baker Monthly	Strontium-90	22	29	28	[b] —
	Cesium-137	115	105	135	100
Coos Bay Monthly	Strontium-90	43	29	21	—
	Cesium-137	135	105	90	65
Eugene Monthly	Strontium-90	14	12	18	—
	Cesium-137	125	110	95	75
Medford Monthly	Strontium-90	15	22	13	—
	Cesium-137	125	145	90	55
Nyssa Monthly	Strontium-90	25	31	18	—
	Cesium-137	125	130	90	60
Portland composite Weekly	Strontium-90	42	28	[c] 27	[c] 20
	Cesium-137	223	197	143	96
Portland local producer Weekly	Strontium-90	24	33	36	—
	Cesium-137	168	160	134	90
Redmond Monthly	Strontium-90	—	20	20	—
	Cesium-137	100	120	80	65
Tillamook Monthly	Strontium-90	—	29	37	—
	Cesium-137	340	190	160	180

[a] Iodine-131 and barium-140 concentrations were below the lower limit of detection of 15 pc/liter.
[b] Dash indicates no analysis performed.
[c] Analyses performed by Public Health Service.

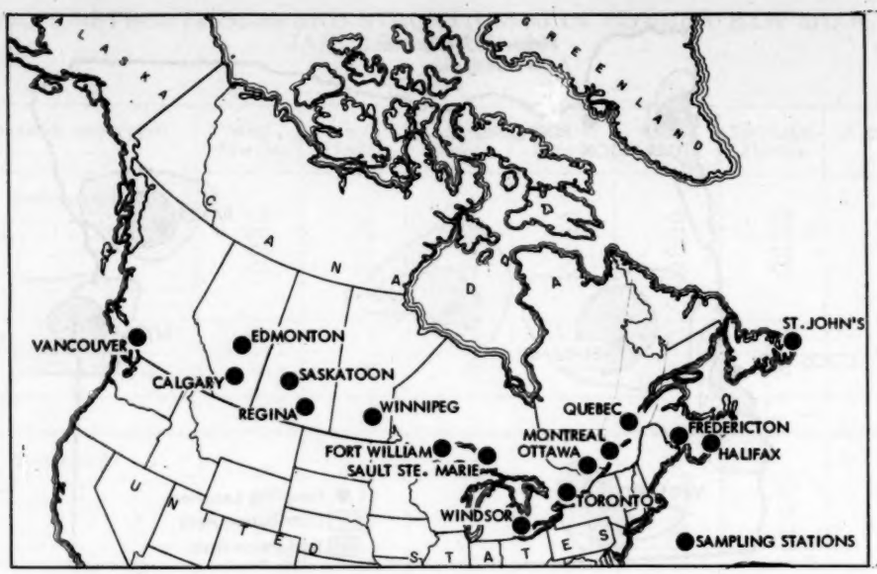

FIGURE 7.—CANADIAN MILK SAMPLING STATIONS

5. Canadian Milk Network[4] November 1964

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 7) in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine-131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450 degrees C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

[4] Data from *Radiation Protection Programs*, Vol. 2, No. 12:25–30 Radiation Protection Division, Canadian Department of National Health and Welfare (Dec. 1964).

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 9.

TABLE 9.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 10 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had < 5 pc/liter.

TABLE 10.—RADIONUCLIDES IN CANADIAN WHOLE MILK, OCTOBER 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.20	1.6	27.9	93
Edmonton	1.16	1.6	23.6	94
Ft. William	1.16	1.7	47.2	172
Fredericton	1.16	1.7	35.1	179
Halifax	1.14	1.7	52.3	218
Montreal	1.14	1.6	29.9	138
Ottawa	1.16	1.6	25.4	108
Quebec	1.14	1.7	45.2	214
Regina	1.12	1.7	31.4	104
St. John's, Nfld	1.12	1.6	40.4	177
Saskatoon	1.12	1.6	30.7	100
Sault Ste. Marie	1.18	1.6	37.6	162
Toronto	1.16	1.6	14.6	77
Vancouver	1.23	1.6	44.2	264
Windsor	1.18	1.6	13.5	67
Winnipeg	1.12	1.5	29.9	128
Average	1.16	1.6	33.1	143

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, DECEMBER 1963–NOVEMBER 1964

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation doses to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to world-wide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*3*,*4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium-90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium-90 to calcium in milk in a particular locality by 1.5".[1] Thus, a rough index of the total dietary intake of strontium-90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine-131, milk can be considered the major source of intake because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allow time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium-89 is more complicated. Its half-life of about 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake. However, since the time from production to consumption of milk is generally much shorter than for most other food products, the short half-life of strontium-89 would cause milk to contribute relatively more of the total intake of strontium-89 than of strontium-90.

[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

TABLE 1.—AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, FOR THE TWELVE MONTH PERIODS NOVEMBER 1963–OCTOBER 1964[a] AND DECEMBER 1963–NOVEMBER 1964[b]

[pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Nov 1963–Oct 1964	Dec 1963–Nov 1964	Nov 1963–Oct 1964	Dec 1963–Nov 1964	Nov 1963–Oct 1964	Dec 1963–Nov 1964	Nov 1963–Oct 1964	Dec 1963–Nov 1964
Ala:	Montgomery	3	3	23	23	0	0	84	82
Alaska:	Palmer	6	6	23	21	0	0	141	130
Ariz:	Phoenix	3	3	4	4	0	0	25	25
Ark:	Little Rock	4	3	45	44	0	0	129	123
Calif:	Sacramento	3	3	8	8	0	0	48	45
	San Francisco	4	3	10	10	0	0	54	51
C. Z:	Cristobal	3	3	5	5	0	0	50	51
Colo:	Denver	4	4	19	19	0	0	91	89
Conn:	Hartford	3	3	22	21	0	0	148	142
Del:	Wilmington	3	3	23	23	0	1	123	119
D. C:	Washington	3	3	19	19	0	0	86	82
Fla:	Tampa	3	3	16	15	0	0	236	232
Ga:	Atlanta	4	3	31	31	0	0	136	134
Hawaii:	Honolulu	3	3	11	12	0	0	78	77
Idaho:	Idaho Falls	11	10	27	27	0	0	168	162
Ill:	Chicago	3	3	19	19	0	0	115	112
Ind:	Indianapolis	3	3	21	21	0	1	98	95
Iowa:	Des Moines	6	5	25	25	0	0	91	87
Kans:	Wichita	5	4	21	21	0	0	66	63
Ky:	Louisville	4	3	31	30	0	0	91	86
La:	New Orleans	4	4	51	51	0	0	144	139
Maine:	Portland	3	3	31	30	0	1	201	194
Md:	Baltimore	3	3	22	22	0	0	99	96
Mass:	Boston	3	3	33	32	0	0	223	213
Mich:	Detroit	3	3	19	18	1	2	113	109
	Grand Rapids	3	3	21	21	0	1	124	120
Minn:	Minneapolis	9	7	33	32	0	0	147	141
Miss:	Jackson	5	4	41	41	0	0	107	104
Mo:	Kansas City	7	6	28	27	0	0	81	77
	St. Louis	5	5	23	23	0	0	82	78
Mont:	Helena	6	5	26	25	1	1	175	166
Nebr:	Omaha	6	5	26	26	0	0	95	90
Nev:	Las Vegas	5	5	10	10	1	1	73	72
N. H:	Manchester	3	3	32	30	0	1	236	226
N. J:	Trenton	3	3	19	19	0	1	114	110
N. Mex:	Albuquerque	3	3	11	11	1	1	54	53
N. Y:	Buffalo	3	3	20	20	0	0	141	136
	New York	4	3	26	25	0	1	159	153
	Syracuse	[c] 3	[d] 3	[c] 20	[d] 20	[c] 0	[d] 0	[c] 139	[d] 134
N. C:	Charlotte	4	3	36	36	0	0	112	109
N. Dak:	Minot	14	12	57	56	0	0	152	149
Ohio:	Cincinnati	3	3	23	23	0	0	92	90
	Cleveland	3	3	21	21	0	0	113	110
Okla:	Oklahoma City	3	3	23	23	0	0	70	68
Ore:	Portland	8	6	31	30	0	0	164	154
Pa:	Philadelphia	3	3	20	20	0	0	119	115
	Pittsburgh	3	3	29	29	0	0	148	143
P. R:	San Juan	3	3	12	12	0	0	73	72
R. I:	Providence	3	3	25	24	0	0	163	157
S. C:	Charleston	3	3	32	32	0	0	127	124
S. Dak:	Rapid City	8	6	43	41	0	0	152	146
Tenn:	Chattanooga	5	4	41	41	0	0	120	116
	Memphis	3	3	32	32	0	0	74	70
Tex:	Austin	3	3	9	9	0	0	41	39
	Dallas	3	3	20	19	0	0	66	62
Utah:	Salt Lake City	8	6	27	25	0	0	178	172
Vt:	Burlington	3	3	26	26	1	2	178	170
Va:	Norfolk	3	3	18	18	0	0	94	91
Wash:	Seattle	7	7	26	26	0	0	152	146
	Spokane	8	6	29	28	0	0	142	136
W. Va:	Charleston	4	3	27	26	0	0	81	78
Wis:	Milwaukee	3	3	18	18	0	1	130	125
Wyo:	Laramie	8	8	21	20	0	0	107	104
Network average		4	4	24.5	24.1	<10	<10	118	113

Note: Annual averages for Barium-140 at each station were <10.

[a] Annual averages were computed on basis of 53 weekly averages.

[b] Annual averages were computed on basis of 52 weekly averages.

[c] Annual averages were computed on basis of 49 weekly averages. No samples were collected during July 1964.

[d] Annual averages were computed on basis of 48 weekly averages. No samples were collected during July 1964.

The relative contribution of milk to the total dietary intake of cesium-137 is not well defined and depends principally on the amount of freshly deposited cesium-137 on products used for human and animal consumption, and the progress of cesium-137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

2 Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

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STRONTIUM-90 IN TRI-CITY DIETS, MAY–JULY 1964[1]

Health and Safety Laboratory, AEC

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U. S. Department of Agriculture (*1*) the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data (*1*) are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results obtained from the May-July 1964 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

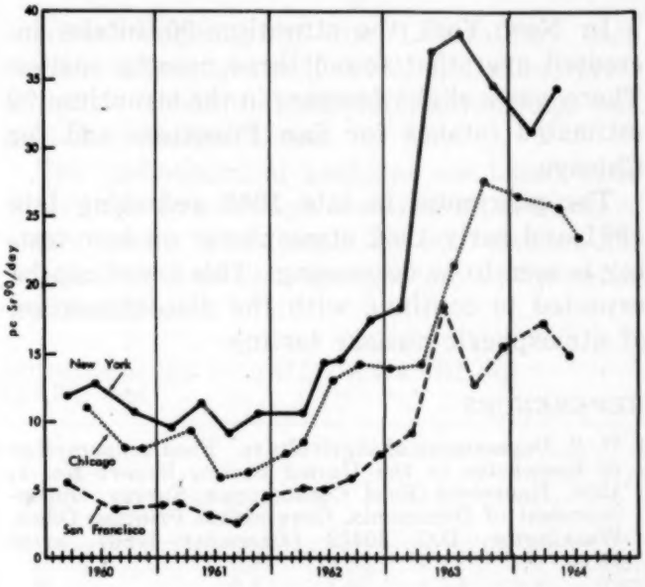

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

Discussion

The previously noted geographic distribution pattern of strontium-90 in the diet is seen to persist as it has since the initial samplings in 1960: Levels have been highest in New York City and lowest in San Francisco. Due in part to its high annual consumption, milk continues to be the predominant source of strontium-90 in diet.

[1] Data from *Fallout Program Quarterly Summary Report, HASL–155*:208–10, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (January 1, 1965) price $4.00.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE, -MAY–JULY 1964 SAMPLING

Food category	Average U.S. consumption		New York City May 1964		Chicago July 1964		San Francisco June 1964	
	diet (kg/yr)	Calcium (g/yr)	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr
Bakery products	37	37.0	29.8±1.6	1103	40.3±1.5	1491	26.3±1.5	973
Whole grain products	11	10.0	87.9±2.3	967	83.3±1.9	916	50.9±2.1	560
Eggs	16	9.1	6.5±0.2	104	9.8±0.2	157	1.8±0.1	28
Fresh vegetables	43	15.0	20.3±0.5	873	13.3±0.5	572	22.4±0.6	963
Root vegetables	17	6.1	8.6±0.5	146	7.0±0.3	119	6.9±0.6	117
Milk	221	234.3	32.0±0.8	7,072	16.2±0.6	3,580	8.7±0.5	1,923
Poultry	17	9.2	2.8±0.2	48	3.5±0.8	60	2.2±0.1	37
Fresh fish	8	10.8	0.6±0.1	5	2.1±0.1	17	0.6±0.1	5
Flour	43	8.6	32.6±0.6	1,402	21.2±0.4	912	12.7±0.4	546
Macaroni	3	0.7	16.6±0.5	50	28.0±0.5	84	12.4±0.5	37
Rice	3	1.1	4.4±0.2	13	6.1±0.2	18	0.4±0.1	1
Meat	73	10.9	1.7±0.4	124	2.2±0.1	161	2.1±0.1	153
Shellfish	1	0.8	2.7±0.1	3	1.4±0.1	1	4.5±0.2	4
Dried beans	3	2.9	36.0±2.2	108	35.6±2.0	107	13.6±1.6	41
Fresh fruit	68	12.6	8.0±0.3	544	4.2±0.2	286	0.4±0.1	27
Potatoes	45	5.8	7.8±0.7	351	3.1±0.3	140	2.6±0.4	162
Canned fruit	26	1.3	2.8±0.2	73	3.6±0.1	94	1.5±0.1	39
Fruit juices	19	1.7	3.2±0.3	61	5.6±0.2	106	4.2±0.3	80
Canned vegetables	20	4.2	6.7±0.6	134	10.9±0.5	218	3.6±0.5	72
Annual intake	674	383	19.6	13,181	13.4	9,039	8.6	5,768
pc Sr^{90}/g Ca in total diet				34.4		23.6		15.0

[a] Error terms are one standard deviation (due to counting).

In New York the strontium-90 intake increased over that found three months earlier. There was a slight decrease in the strontium-90 estimated intakes for San Francisco and for Chicago.

The maximum in late 1963 reflecting late 1961 and early 1962 atmospheric nuclear testing is seen to be decreasing. This trend can be expected to continue with the discontinuation of atmospheric nuclear testing.

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Recent coverage in *Radiological Health Data:*

Period	Issue
Thirteenth sampling (May–July 1963)	*March 1964*
Fourteenth sampling (August–October 1963)	*June 1964*
Fifteenth sampling (November 1963–January 1964)	*September 1964*
Sixteenth Sampling (February 1964–April 1964)	*December 1964*

ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS, JANUARY–JUNE 1964

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other source. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every two months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitions indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determinations.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium-89 and strontium-90; radium-226 analysis; and gamma spectroscopy of the entire wet sample.

TABLE 1.—ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[a] JANUARY–FEBRUARY 1964

City	Kg/capita per day[b]	pc/capita/day							grams/capita/day[c, d]			
		Sr-89	Sr-90	Ra-226	Cs-137	Zr-95	Mn-54	Ce-141, Ce-144	K	Na	Ca	Sr
Bakersfield	2.1	8.1	12	0.7	54	48	—[e]	0.8	2.7	3.6	0.8	0.003
Berkeley	2.5	1.5	17	0.5	77	80	—	5.8	3.5	4.0	0.6	0.004
Bishop	1.0	6.2	19	2.6	63	35	1.2	2.0	2.3	2.5	0.7	0.004
Brawley	2.7	4.8	7	1.0	39	44	8.2	7.5	3.6	4.7	1.2	0.006
Crescent City	2.9	24.0	70	1.1	173	67	5.1	11.0	3.7	4.0	1.5	0.007
Eureka	3.1	—	—	3.1	79	17	4.6	7.0	2.3	3.0	—	0.003
Fresno	2.7	3.9	17	2.3	41	41	13	6.5	3.7	5.2	1.2	0.005
Los Angeles	1.9	5.6	5	2.5	—	—	—	—	1.2	3.5	0.7	0.003
Needles	1.3	0.7	15	1.3	73	3.7	—	2.5	2.7	4.8	1.0	0.003
Quincy	2.5	0	15	0.8	88	51	1.6	2.4	1.7	4.1	1.1	0.004
Redding	1.5	2.2	2.3	0.6	41	31	3.1	1.0	2.2	5.3	0.9	0.008
Sacramento	2.7	1.2	21	0.8	81	49	9.3	0.8	3.2	4.7	1.2	0.004
Salinas	2.4	3.5	11	0.1	144	40	4.6	0.4	3.1	2.6	0.7	0.003
San Bernardino	2.6	0.6	15	1.2	—	—	—	—	1.9	4.9	0.9	0.005
San Diego	2.1	0.3	—	1.6	47	44	3.4	3.6	3.1	7.8	1.1	0.012
San Luis Obispo	1.7	0.4	2	1.5	28	31	5.2	4.2	2.0	3.1	1.2	0.005
Santa Barbara	3.0	3.0	6	0.2	—	—	—	—	1.6	2.2	0.4	0.003
Santa Rosa	2.0	2.0	13	0.3	59	69	—	3.8	2.8	2.7	1.0	0.003
Susanville	2.1	7.9	11	—	80	41	2.2	3.1	1.4	3.6	0.8	0.003
Ukiah	2.2	4.9	15	1.0	55	54	13	2.4	3.1	2.6	1.7	0.003

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive K-40.
[d] Stable strontium consists of Sr-88—82.7 percent; Sr-87—7.0 percent; Sr-86—9.8 percent; Sr-84—0.5 percent; total—100.0 percent.
[e] Dash indicates sample lost in laboratory procedures.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in tables 1–3 for January through June 1964 (*2*).

It should be noted that levels of radioactvity were observed to be far below those levels for which consideration should be given to protective health action.

TABLE 2.—ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[a] MARCH–APRIL 1964

City	Kg/capita per day [b]	pc/capita/day							grams/capita/day [c, d]			
		Sr-89	Sr-90	Ra-226	Cs-137	Zr-95	Mn-54	Ce-141, Ce-144	K	Na	Ca	Sr
Bakersfield	2.2	8.0	13	2.7	108	52	3.3	0	3.3	4.6	1.3	0.07
Berkeley	2.6	1.1	27	1.0	86	44	[b]	0	3.2	4.9	1.4	0.07
Bishop	1.4	2.0	8	0.9	51	28	7.1	7.0	1.8	2.4	0.5	0.04
Brawley	2.6	3.3	12	2.0	27	44	0	22	3.0	4.4	1.4	0.08
Crescent City	2.3	5.5	68	2.9	—	—	—	—	3.2	4.1	1.2	0.06
Eureka	2.1	6.3	38	0.7	80	52	8.9	18	2.5	3.1	1.3	0.07
Fresno	2.3	0	33	1.3	—	—	—	—	3.5	5.5	1.3	0.08
Los Angles	2.7	0	14	0.2	87	56	—	0	2.8	3.7	0.8	0.06
Quincy	1.3	3.3	7	0.9	—	—	—	—	1.8	2.8	0.5	0.02
Redding	2.2	10	14	2.4	55	35	—	95	2.8	4.3	0.9	0.06
Sacramento	2.6	0	15	1.4	85	36	0	2.6	4.8	8.3	1.7	0.13
Salinas	2.3	4.2	18	0.9	55	39	0	1.6	2.9	3.6	0.8	0.06
San Bernardino	1.9	8.0	11	0.6	48	36	2.7	3.8	3.0	4.1	1.0	0.07
San Diego	2.2	3.5	2	0.3	45	42	0.7	0	2.8	3.6	0.7	0.07
San Luis Obispo	1.6	1.7	10	0.8	38	33	8.3	6.9	2.0	3.2	0.7	0.05
Santa Barabara	1.9	0	15	0.6	62	31	0	0	2.3	3.1	1.0	0.02
Santa Rosa	2.5	0	27	0.6	77	34	0	0	3.1	3.3	1.4	0.04
Susanville	2.3	3.9	14	0.6	108	52	3.3	0	2.3	3.1	0.8	0.03
Ukiah	2.1	0.6	14	1.5	67	41	—	0	3.0	2.7	0.9	0.04

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Dash indicates sample lost in laboratory procedures.

TABLE 3.—ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS,[a] MAY–JUNE 1964

City	Kg/capita per day [b]	pc/capita/day							grams/capita/day [c, d]			
		Sr-89	Sr-90	Ra-226	Cs-137	Zr-95	Mn-54	Ce-141, Ce-144	K	Na	Ca	Sr
Bakersfield	2.2	3.1	13	0.5	64	54	0	28	3.0	4.1	1.2	0.03
Berkeley	2.9	7.0	14	1.2	60	37	0	34	3.9	5.3	1.1	0.09
Bishop	1.4	3.5	9.0	0.4	37	27	0.4	30	2.0	2.1	0.6	0.02
Brawley	2.4	0	41	0.1	75	3.0	[b]	87	3.3	4.3	1.0	0.04
Crescent City	2.2	0	38	0.8	93	28	16	72	2.6	3.3	0.9	0.04
Eureka	2.3	—	—	1.1	92	37	—	0	2.8	3.2	1.2	0.05
Fresno	2.3	0	28	0.6	65	34	1.6	0	3.0	4.2	0.9	0.04
Los Angles	2.7	0.2	11	0.8	61	47	0	18	3.0	3.2	0.8	0.02
Needles	2.3	0	15	0.6	63	27	10	0	3.0	3.6	1.0	0.03
Quincy	1.8	0	17	0.6	103	144	106	0	2.3	4.6	0.4	0.07
Redding	2.5	1.0	27	1.0	100	39	20	0	3.3	5.7	1.1	0.04
Sacramento	3.4	13	17	1.8	85	41	12	72	3.9	6.8	1.3	0.06
Salinas	2.4	0	27	0.6	92	9.3	3.2	11	3.4	5.7	0.7	0.07
San Bernardino	2.1	0.4	11	0.9	52	39	0.5	8.2	3.2	3.8	0.9	0.03
San Diego	2.0	0	20	1.6	65	30	1.1	0	2.8	3.8	1.1	0.04
San Luis Obispo	1.4	0	14	0.8	51	44	0	0	1.9	3.8	0.6	0.03
Santa Barbara	1.8	0	14	1.4	—	—	—	—	2.5	3.6	0.8	0.05
Santa Rosa	2.4	0	36	2.0	39	32	0	72	2.8	3.3	0.9	0.03
Susanville	2.3	0	17	0.7	95	35	4.3	0.5	3.0	3.2	0.8	0.03
Ukiah	2.3	11	20	0.6	80	32	14	68	3.1	3.9	1.5	0.08

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Dash indicates sample lost in laboratory procedures.

REFERENCES

1. Bureau of Radiological Health, State of California, Department of Public Health. Rad Health News 3:10 (July 1964). 2151 Berkeley Way, Berkeley 4, California.
2. Ibid., p. 34.

Section III—Water

Gross Radioactivity and Strontium-90 in Surface Waters of the United States, September 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of February 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–7*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counter.

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FIGURE 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, OCTOBER 1964

Results

Table 1 presents September 1964 results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the June 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

Strontium-90 determinations and results

Beginning in 1959, strontium-90 analyses of the total solids of surface waters were made quarterly on three-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where quarterly analyses were continued. The method used for determining strontium-90 is a modification of a procedure described by Harley (*10*). The yttrium-90 together with an yttrium carrier is precipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Table 2 presents the results of quarterly analyses of strontium-90 concentrations in U.S. surface waters for July-September 1964 as well as results for the previous three quarters for comparative purposes. The stations are arranged in the table according to their relative locations on the river, the first station being closest to the headwaters. Floyd and Weaver summarized the strontium-90 results

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, SEPTEMBER 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	4	14	18	1	1	2
Apalachicola River:						
Chattahoochee, Fla.	2	2	4	0	0	0
Arkansas River:						
Coolidge, Kansas	6	43	49	0	12	12
Ponca City, Okla.	53	31	84	9	0	9
Atchafalaya River:						
Morgan City, La.	7	16	23	0	1	1
Bear River:						
Preston, Idaho	0	8	8	0	2	2
Big Horn River:						
Hardin, Mont.	7	9	16	1	10	11
Chattahoochee River:						
Atlanta, Ga.	5	9	14	<1	0	<1
Columbus, Ga.	2	7	9	0	0	0
Lanett, Ala.	2	4	6	0	0	0
Chena River:						
Fairbanks, Alaska	1	8	9	0	1	1
Clinch River:						
Clinton, Tenn.	0	7	7	0	0	0
Kingston, Tenn.	12	23	35	0	0	0
Colorado River:						
Loma, Colo.	4	0	4	1	17	18
Page, Ariz.	1	34	35	0	5	5
Parker Dam, Calif-Ariz.	1	19	20	0	10	10
Columbia River:						
Wenatchee, Wash.	0	11	11	0	0	0
Pasco, Wash.	123	981	1104	0	1	1
Clatskanie, Ore.	18	150	168	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn.	0	9	9	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa.	1	7	8	0	0	0
Escambia River:						
Century, Fla.	5	8	13	1	0	1
Great Lakes:						
Duluth, Minn.	0	1	1	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	4	13	17	0	0	0
Illinois River:						
Grafton, Ill.	6	17	23	1	2	3
Kansas River:						
De Soto, Kans.	51	33	84	7	1	8
Maumee River:						
Toledo, Ohio	4	18	22	1	1	2
Mississippi River:						
St. Paul, Minn.	1	27	28	0	2	2
E. St. Louis, Ill.	8	19	27	1	2	3
New Roads, La.	13	22	35	2	1	3
New Orleans, La.	11	19	30	1	1	2
Missouri River:	0	16	16	0	1	1
Williston, N. Dak.						
St. Joseph, Mo.	5	22	27	0	4	4
North Platte River:	34	31	65	10	4	14
Henry, Nebr.						
Ohio River:	3	34	37	0	21	21
Cairo, Ill.						
Toronto, Ohio	0	6	6	0	1	1
Platte River:	2	16	18	0	0	0
Plattsmouth, Nebr.						
Potomac River:	58	22	80	12	3	15
Washington, D.C.						
Red River, North:	2	11	13	0	0	0
Grand Forks, N. Dak.						
Red River, South:	2	30	32	0	1	1
Alexandria, La.						
Rio Grande River:	13	20	33	2	1	3
El Paso, Tex.						
Laredo, Tex.	96	29	125	25	0	25
San Joaquin River:	418	16	434	73	1	74
Vernalis, Calif.						
San Juan River:	6	24	30	1	7	8
Shiprock, N. Mex.						
Savannah River:	855	26	881	264	6	270
Port Wentworth, Ga.						
Snake River:	5	13	18	0	0	0
Wawawai, Wash.						
South Platte River:	3	11	14	0	2	2
Julesburg, Colo.						
Susquehanna River:	3	51	54	0	18	18
Conowingo, Md.						
Tennessee River:	2	9	11	0	0	0
Lenoir City, Tenn.						
Chattanooga, Tenn.	1	7	8	0	0	0
Bridgeport, Ala.	2	10	12	0	<1	<1
Pickwick Landing, Tenn.	0	14	14	1	0	1
Tombigbee River:	2	11	13	0	<1	<1
Columbus, Miss.						
Wabash River:	3	8	11	0	0	0
New Harmony, Ind.						
Yellowstone River:	8	13	21	0	<1	<1
Sidney, Mont.						
	25	18	43	3	3	6
Maximum	855	981	1104	264	21	270
Minimum	0	0	1	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*11*).

Sixty-seven quarterly composite samples were analyzed for strontium-90 activity in July-September 1964. The arithmetic mean for these results was 2.8 pc/liter. The mean for 69 results of the previous quarter was 3.0 pc/liter. These values are essentially the same, although different sets of stations were sampled in each quarter.

The highest strontium-90 result for this quarter (8.2 pc/liter) occurred, as it did the previous quarter, at Grand Forks, North Dakota (Red River, North). While there are no standards for strontium-90 activity of total solids in surface water, the Public Health Service Drinking Water Standards set the limit for strontium-90 concentrations in drinking water at 10 pc/liter (*11*). This limit for public water supplies is greater than the highest level observed during July-September 1964.

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at only two stations, the Pasco, Washington, station and the Clatskanie, Oregon, station on the Columbia River. The dissolved beta activity values observed were 981 and 150 pc/liter, respectively.

Dissolved alpha activity, associated with the dissolving of natural surface minerals by water, ranged from 0 to 21 pc/liter. Four stations had monthly average dissolved alpha activity greater than 10 pc/liter.

TABLE 2.—QUARTERLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS, OCTOBER 1963–SEPTEMBER 1964

[Concentrations in pc/liter]

Station	Oct.–Dec. 1963	Jan.–Mar. 1964	Apr.–June 1964	July–Sept. 1964
Allegheny River:				
Pittsburgh, Pa	2.8		2.3	
Animas River:				
Cedar Hill, N. Mex		1.7		1.5
Apalachicola River:				
Chattahoochee, Fla		1.5		1.6
Arkansas River:				
Coolidge, Kans		0.9		2.5
Ponca City, Okla	4.4		6.0	
Fort Smith, Ark		3.5		4.8
Little Rock, Ark	4.4		4.2	
Pendleton Ferry, Ark	4.3		4.4	
Atchafalaya River:				
Morgan City, La.[a]				4.0
Bear River:				
Preston, Idaho		1.1		2.5
Big Horn River:				
Hardin, Mont	2.3		6.4	
Big Sioux River:				
Sioux Falls, S. Dak	5.0	2.8		4.6
Chattahoochee River:				
Atlanta, Ga	1.7		2.4	
Columbus, Ga	1.7		2.0	
Lanett, Ala		1.7		1.8
Chena River:				
Fairbanks, Alaska	0.2		0.8	
Clearwater River:				
Lewiston, Idaho		0.8		1.0
Clinch River:				
Clinton, Tenn		2.0		1.3
Kingston, Tenn	6.5	7.5	4.9	3.3
Colorado River:				
Loma, Colo	1.4		2.5	
Page, Ariz		5.9		4.9
Boulder City, Nev	1.5		1.6	
Parker Dam, Calif-Ariz		1.9		2.2
Yuma, Ariz	1.1		1.0	
Columbia River:				
Northport, Wash		1.5		2.1
Wenatchee, Wash	2.8		1.2	
Pasco, Wash	3.4	3.1	1.7	2.5
McNary Dam, Ore	2.5	2.2	1.1	1.6
Bonneville, Ore		2.0		1.6
Clatskanie, Ore	1.6		1.0	
Connecticut River:				
Wilder, Vt		1.3		1.4
Northfield, Mass	1.8		1.5	
Enfield Dam, Conn		1.7		1.9
Coosa River:				
Rome, Ga.[b]				1.7
Cumberland River:				
Clarksville, Tenn.[c]				
Cheatham Lock, Tenn.[d]				1.7
Cuyahoga River:				
Cleveland, Ohio		4.3		4.5
Delaware River:				
Martins Creek, Pa	1.6		1.5	
Trenton, N. J		1.8		1.7
Philadelphia, Pa	2.1		2.0	
Escambia River:				
Century, Fla	1.2		1.8	
Great Lakes:				
Duluth, Minn	0.7		0.7	
Sault Ste. Marie, Mich		0.8		0.8
Milwaukee, Wis	0.8		1.2	
Gary, Ind		1.2		1.0
Port Huron, Mich	1.2		1.5	
Detroit, Mich		1.4		1.6
Buffalo, N. Y	5.0		2.7	
Green River:				
Dutch John, Utah		4.6		4.4
Hudson River:				
Poughkeepsie, N. Y	5.0		2.1	
Illinois River:				
Peoria, Ill	2.3		3.8	
Grafton, Ill		3.8		3.4
Kanawha River:				
Winfield Dam, W. Va		1.1		1.8
Kansas River:				
De Soto, Kans	5.2		5.9	
Klamath River:				
Keno, Ore	1.8		1.7	
Little Miami River:				
Cincinnati, Ohio	1.4	3.3		2.4
Maumee River:				
Toledo, Ohio	2.7		4.2	
Merrimack River:				
Lowell, Mass		1.8		2.6
Mississippi River:				
St. Paul, Minn	4.3	3.2		5.3
Dubuque, Iowa	3.7		5.2	
Burlington, Iowa	4.3	2.8		4.4
E. St. Louis, Ill	3.8		4.9	
Cape Girardeau, Mo		2.9		4.2
W. Memphis, Ark	3.6		4.3	
Vicksburg, Miss		2.7		3.7
Delta, La	3.4		3.6	
New Roads, La.[e]			3.6	
New Orleans, La		2.8		3.7
Missouri River:				
Williston, N. Dak	2.8		3.1	
Bismarck, N. Dak		3.9		4.0
Yankton, S. Dak	3.3		4.3	
Omaha, Nebr		3.3		4.4
St. Joseph, Mo	3.4		6.4	
Kansas City, Kans		2.9		5.8
Missouri City, Mo	4.1		9.4	
St. Louis, Mo		3.1		5.0
Monongahela River:				
Pittsburgh, Pa	3.3		2.1	
North Platte River:				
Henry, Nebr	0.7		3.3	
Ohio River:				
Toronto, Ohio	2.8		2.3	
Addison, Ohio		2.2		3.4
Huntington, W. Va	3.0		2.2	
Cincinnati, Ohio		1.6		3.2
Louisville, Ky	4.0		2.6	
Evansville, Ind		2.5		3.0
Cairo, Ill	2.8		3.4	
Ouachita River:				
Bastrop, La		3.0		2.5
Pend Oreille River:				
Albeni Falls Dam, Idaho	1.3		1.2	
Platte River:				
Plattsmouth, Nebr		2.1		4.8
Potomac River:				
Williamsport, Md	1.7		1.3	
Great Falls, Md		1.4		1.7
Washington, D. C		1.2		1.9
Rainy River:				
Baudette, Minn	4.1		4.0	
International Falls, Minn	3.8		5.0	
Raritan River:				
Perth Amboy, New Jersey (5-ft. Below Surface)				
Perth Amboy, New Jersey (5-ft. Above Bottom)				
Red River, North:				
Grand Forks, N. Dak	7.1	4.9	9.4	8.2
Red River, South:				
Denison, Tex		5.8		6.4
Index, Ark	4.3		5.4	
Bossier City, La		4.4		5.9
Alexandria, La	4.1		4.4	
Rio Grande River:				
Alamosa, Colo	0.8		1.9	
El Paso, Tex		0.6		2.7
Laredo, Tex	2.4		5.6	
Brownsville, Tex		2.6		2.6
Roanoke River:				
John H. Kerr Resr/Dam, Va	2.6		1.5	
Sabine River:				
Ruliff, Tex		2.5		2.7
Sacramento River:				
Courtland, Calif	1.0	1.0		0.9
St. Lawrence River:				
Massena, N. Y		1.6		1.6
San Joaquin River:				
Vernalis, Calif	1.5		1.0	
San Juan River:				
Shiprock, N. Mex	2.1		2.9	
Savannah River:				
North Augusta, So. Car		1.7		2.1
Port Wentworth, Ga	2.4	1.7	2.3	2.6
Schuylkill River:				
Philadelphia, Pa		1.4		1.6
Shenandoah River:				
Berryville, Va	1.0		1.1	
Ship Creek:				
Anchorage, Alaska		0.4		0.2
Snake River:				
Ice Harbor Dam, Wash		1.0		1.1
Wawawai, Wash	0.7		1.0	
Payette, Idaho	0.8		0.9	
South Platte River:				
Julesburg, Colo	1.8		1.6	
Spokane River:				
Post Falls, Idaho		1.3		0.9
Susquehanna River:				
Sayre, Pa		1.3		1.7
Conowingo, Md	3.0		1.3	
Tennessee River:				
Lenoir City, Tenn	2.1		1.6	
Chattanooga, Tenn	2.2	2.0	2.3	1.9
Bridgeport, Ala	2.2		1.5	
Pickwick Landing, Tenn		2.1		2.4
Tombigbee River:				
Columbus, Miss		3.1		2.0
Truckee River:				
Farad, Calif	1.0		1.2	
Verdigris River:				
Nowata, Okla	6.0		6.6	
Wabash River:				
New Harmony, Ind	2.5		4.2	
Willamette River:				
Portland, Ore	0.5		0.3	
Yakima River:				
Richland, Wash		0.3		0.3
Yellowstone River:				
Sindey, Mont		1.9		3.2
Maximum	7.1	7.5	9.4	8.2
Minimum	0.2	0.3	0.3	0.2

[a] Activated 5-15-64.
[b] Activated 8-64.
[c] Deactivated 7-22-64.
[d] Relocated
[e] Activated 5-15-64.

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (*11*). Analysis of the preliminary September 1964 data indicates elevated levels of alpha and beta activity (pc/liter) in the suspended solids fraction. The monthly average suspended alpha and beta activities in the San Juan River at Shiprock, New Mexico, were 264 and 855 pc/liter, respectively. At El Paso, Texas, and Laredo, Texas, on the Rio Grande the suspended alpha activities were 25 and 73 pc/liter and the suspended beta activities were 96 and 418 pc/liter, respectively. The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling station. The samples associated with these unusually high averages contained large quantities of suspended solids. Thus, only quite small aliquots could be used in the laboratory determinations to avoid excessive beta self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting errors associated with standard counting periods, can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the samples discussed above was determined and found to be comparable to specific activities observed normally in samples from this station. The apparent increased activity, therefore, may be attributed to the extremely high suspended solids content of the sample and considered essentially of natural origin.

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90 respectively.

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[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOACTIVITY IN CALIFORNIA SURFACE WATERS,[1] JANUARY–JUNE 1964

Bureau of Radiological Health,
State of California
Department of Public Health

Gross beta results obtained by the Bureau of Radiological Health in its monitoring of California surface water during the period January to June 1964 are summarized below. The importance of this facet of the Bureau's environmental surveillance program stems from the fact that most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams, any radioactivity that may be added by the discharge of sewage or industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters, (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

It is necessary to monitor domestic water supplies on a continuing basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The Bureau has established a monthly sampling schedule whereby 500-ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of approximately six months to make up a composite of approximately five gallons for specific radionuclide analysis.

[1] Data from 'Radiological Health News," Vol. 3 No. 3, July, 1964, State of California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

Analytical procedures

Radionuclide analyses of water are carried out in the Sanitation and Radiation Laboratory. All measurements of alpha and alpha-plus-beta activities are made with windowless gas-flow proportional counters. Counting methods used are in accordance with U.S. Public Health Service recommended procedures (*1*).

Individual samples are evaporated down to dryness and the residue ashed at 450° C. The ashed sample is dissolved and transferred to an aluminum planchet for beta and alpha-plus-beta counting. Gamma emitting radionuclides are determined for composite samples. Indi-

FIGURE 1.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

TABLE 1.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, JANUARY–JUNE 1964

[Concentrations in pc/liter]

Sampling station	January	February	March	April	May	June
Antioch	[a] 4	[a] 2	[a] 23	97	36	74
Clearlake Highlands	[a] 0	[b] —	[a] 8	[a] 25	—	88
Crescent City	[a] 3	[a] 0	[a] 0	[a]	[a] 8	44
Escondido	[a] 6	[a] 15	25	[a] 24	30	29
Eureka	[a] 5	[a] 6	[a] 15	47	[a] 9	
Fort Bragg	—	—	—	40	[a] 14	2
Fresno:						
Lake Millerton	[a] 15	25	26	30	32	70
Mariposa	[a] 13	[a] 19	[a] 12	108	88	36
Metropolitan Water District of Southern California:						
Lake Havasu	30	—	[a] 17	—	[a]	19
Lake Matthews	36	[a] 10	[a] 19	[a] 12	30	[a] 12
Monterey	[a] 16	[a] 13	[a] 0	50	[a] 9	[a] 11
Napa	[a] 15	[a] 1	[a] 6	—	38	[a] 20
North Marin Water District	[a] 24	[a] 9	[a] 26	56	69	47
Oroville:						
Wyandotte Irrigation District	—	—	24	163	—	[a] 25
California Water Service	—	7	—	—	27	—
Placerville	30	—	[a] 13	—	39	71
Redding	[a] 15	[a] 0	[a] 6	55	38	48
Sacramento	[a] 18	[a] 10	[a] 5	30	34	
San Francisco:						
Alameda East	26	22	27	94	33	78
Brightside Weir	[a] 2	[a] 1	[a] 0	36	[a] 15	101
Calaveras Reservoir	[a] 6	[a] 0	[a] 23	[a] 18	50	25
Crystal Springs Line No. 1	[a, c] 15	[a, c] 14	[a, c] 12	[c] 42	[c] 43	[c] 30
Crystal Springs Line No. 2	[a] 17	—	—	—	77	—
Hetch Hetchy Lombard Reservoir	[a] 27	[a] 9	[a] 21	—	187	72
Moccasin	—	—	[a, c] 15	[a] 21	—	—
San Andreas Line No. 2	—	—	—	[c] 58	[c] 43	[c] 51
San Jose	[a] 0	[a] 0	[a] 0	[a]	39	—
San Luis Obispo	[a] 16	[a] 13	[a] 0	—	—	—
Santa Barbara	—	—	—	42	[a] 15	—
Santa Cruz	[a] 18	30	[a] 10	[a] 17	[a] 21	34
Santa Rosa	[a] 8	[a] 11	[a] 16	72	[a] 17	55
Scotia	[a] 3	[a] 14	[a] 1	51	[a] 15	[a] 11
Tahoe City	[a] 11	[a] 9	—	55	32	—
Vallejo:						
Fleming Hill	53	36	32	61	49	—
Swanzy Reservoir	[a] 21	[a] 0	[a] 5	59	23	—
Vista	—	—	—	—	—	27
Willits	35	30	[a] 10	104	34	30
Yosemite	[a] 1	32	22	72	54	143
Maximum	53	36	32	163	187	143
Minimum	0	0	0	12	8	2

[a] The counting rate of the sample is not equal to at least twice the 95 percent statistical counting error but the value reported is the best available estimate.
[b] Dash indicates no sample collected or analyzed.
[c] Average of more than one sample for the month.

vidual samples are composited in small glass petri dishes. The petri dishes are counted for 100 minutes using a gamma scintillation spectrometer. The quantities of the radionuclides of concern are calculated through the computer solution of eight simultaneous linear equations. Analysis is complicated by the presence of 0.51 Mev gamma radiation of unknown origin which may arise from a radionuclide emitting approximately this gamma energy or annihilation of a positron, where the positron resulted from either direct emission or "pair production".

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in raw surface water in California from January through June 1964. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water has been observed in spite of some increase in fallout.

TABLE 2.—RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA SURFACE WATER, 1960–1963

[Concentrations in pc/liter]

Sampling station and date	$Ba\text{-}La^{140}$	K^{40}	Zn^{65}	$Zr\text{-}Nb^{95}$	Cs^{137}	0.51 Mev	I^{131}	$Ce^{141}\text{-}Ce^{144}$	Sr^{89}	Sr^{90}
Berkeley										
Jan. 61—June 61	[a]				[b] *	*1		*1,220		*0.2
July 61—Dec. 61				16		*			22	[b]
Jan. 62—June 62		*		*		*			*1	*0.1
July 62—Dec. 62	*58		*1	6	*	*1	*	*	3	0.4
Chula Vista										
Feb. 62—July 62		*1		*8		2		183	6	0.7
Aug. 62—Jan. 63		*1	*1	6	*			*1	*2	0.9
Cresent City										
July 60—Dec. 60	*	*	*	*	*	*	*	*		0.1
Jan. 61—June 61			*	*	*	*	*	*		0.1
July 61—Dec. 61		18		8		15		*	1	*0.1
Jan. 62—June 62	*	*	*	*	*	*	*	*	1	*
July 62—Dec. 62	*	*2		33	*			*	2	0.2
Jan. 63—June 63		*	*	3	*	*1	*	*	*1	0.1
Dos Palos										
July 60—Jan. 61	*	*	*	*	*	*	*	*		0.3
July 60—Oct. 61				32		6				0.5
Feb. 62—July 62				*3		*1			2	0.3
July 62—Jan. 63		*6	*	23	*	*1		2	8	0.4
Feb. 63—July 63									*2	0.7
El Centro										
Oct. 60—March 61		4				*				1.2
April 61—Sept. 61	*	*		99		*1			44	0.6
Oct. 61—March 62				3		2		*	48	*0.9
Eureka										
June 60—Nov. 60	*	*	*	*	*	*	*	*		
Jan. 61—June 61				63		*		*763		0.3
Aug. 61—Jan. 62				130		11		145	9	0.3
Jan. 62—July 62				98		3			187	3.6
Oct. 62—Dec. 62									*	0.1
Fresno, Lake Millerton										
July 60—Jan. 61	*	*	*	*	*	*	*	*		0.5
Feb. 61—June 61						20		*		0.2
Aug. 61—Jan. 62	*			44		1		296	3	0.3
Feb. 62—July 62				22		*		*	4	0.5
Aug. 62—Jan. 63				3		1			2	0.6
Feb. 63—July 63		*5		51	*	4		*1	*1	0.6
Los Angeles Dept. of Water and Power										
Jan. 61—July 61					*	*		*8		*0.3
July 61—Dec. 61		*13		92		*2			8	0.2
Jan. 62—June 62				6		1			5	0.4
Metropolitan Water District of Southern Calif.										
Jan. 61—June 61					*	*		*		0.5
July 61—Dec. 61		*		297	*	13		1,970	4	*0.1
Jan. 62—June 62		3		2		*			*	0.7
July 62—Dec. 62		*1	*1	152	*	6	*	*2	10	1.0
Jan. 63—June 63	*	*	*	6	*	1	*	19	5	1.2
Monterey										
July 61—Dec. 61		25		119		18		*	7	0.5
Jan. 62—June 62				15		*1		*	2	0.3
July 62—Jan. 63	*	*	*1	27	*	*		1	*1	0.3
Jan. 63—June 63	*	9	[c] 2	*	1	*	*	3	*	*0.1
Napa										
Feb. 61—July 61						*		*11		0.4
Aug. 61—Jan. 62				2		2			22	0.2
Jan. 62—June 62		*		56	*	1		*	*4	0.2
June 62—Dec. 62	*	*	*1	*4	*	*1		1	3	*
Jan. 63—July 63	*	6	[c] 9	53	2	11	*	5	*2	1.2
North Marin										
Jan. 61—July 61		11				*		*		*0.5
Aug. 61—Dec. 61		34		16		14		*	7	1.1
Jan. 62—July 62						2			5	0.8
July 62—Dec. 62	*	*12	*1	23	*	4		*	9	0.9
Jan. 63—July 63		*7	*	*	*	2	*	*	14	1.2
Redding										
Jan. 61—July 61						*		3		0.1
July 61—Dec. 61				9		*			4	0.3
Jan. 62—June 62		22		16		*2			4	0.3
July 62—Dec. 62				191		32		593	7	0.3
Jan. 63—June 63	*	*3		140	*	6		*	12	0.6
Sacramento										
Aug. 60—Feb. 61						*				0.3
March 61—Sept. 61						8				0.3
Sept. 61—Feb. 62		*		113		*1			39	0.6
March 62—Aug. 62		21		10		3			2	0.3
Sept. 62—Feb. 63	*	*		41	*	3		*1	3	0.5
Feb. 63—June 63	*	7	[c] 2	2	1	3	*	2	*1	0.6
San Diego										
Nov. 60—April 61		7				*		91		0.8
Aug. 61—Dec. 61		*10		*10		*1		*	40	0.5
May 62—Oct. 62	*	*6	*1	46	*	*2	*	*	375	0.9

TABLE 2.—RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA SURFACE WATER, 1960–1963—Continued

[Concentrations in pc/liter]

Sampling station and date	$Ba\text{-}La^{140}$	K^{40}	Zn^{65}	$Zr\text{-}Nb^{95}$	Cs^{137}	0.51 Mev	I^{131}	$Ce^{141}\text{-}Ce^{144}$	Sr^{89}	Sr^{90}
San Francisco										
Dec. 61—May 62	*[a]	*[b]		2		2		*	8	0.4
San Luis Obispo										
May 61—Oct. 61	13			13		13		*		1.2
Jan 62—June 62		4		42		4		351	5	0.7
Santa Barbara										
June 61—Nov. 61		4		1		*		*		*0.7
Dec. 61—June 62				71		4		532	6	0.3
July 62—Nov. 62		*2	*	34	*	5		*2	5	0.6
Santa Cruz										
Nov. 61—April 62	*	*	*2	643	*	6	*	*	154	0.6
Santa Rosa										
July 61—Dec. 61				10		6		*	3	0.2
Jan. 62—June 62				1		*1			*	0.3
July 62—Dec. 62									*	1.1
Jan. 63—July 63		*6	*1	457	*	17	*	*	*	0.3
Vallejo										
Jan. 62—July 62						2			7	0.6
July 62—Dec. 62		*	*2	51	*	5		3	13	0.6
Jan. 63—July 63		47	*[c] 13	27	3	9	*	5	3	1.0
Yosemite										
May 61—Oct. 61										2.0
July 61—Oct. 61				28		5		3,160		0.4
Nov. 61—April 62				8		*			4	0.2
Oct. 62—March 63	*	*	*	87	*	*		*	*3	0.9
Jan. 63—July 63	*	*	*[c] 2	16	1	6	*	2	*14	1.6

[a] Blank spaces indicate no analysis.

[b] Asterisks are used to indicate that the counting rate of the sample is not equal to at least twice the 0.95 error. The value reported is the best available estimate but is not statistically significant. An asterisk alone indicates no activity was detected.

[c] Mn^{54} instead of Zn^{65}.

Table 2 shows specific radionuclide concentrations in California surface waters for 1960-1963 bi-annually by stations.

Table 3 shows maximum radionuclide concentrations in California surface waters for the period 1960-1963. Related values of the International Committee on Radiological Protection Standards (*2*) for continuous population exposure are also shown. No standards are given for potassium-40 which occurs naturally. It is observed that none of the six-month composite raw surface water samples had specific radionuclide concentrations exceeding their respective MPC. For each radionuclide reported the minimum concentration observed was below detectable levels.

TABLE 3.—MAXIMUM OBSERVED RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA SURFACE WATERS AND RELATIVE ICRP STANDARDS

Nuclide	Observed maximum (pc/liter)	MPC (pc/liter)
$Ba\text{-}La^{140}$	58	10,000
K^{40}	34	
Zn^{65}	2	10,000
$Zr\text{-}Nb^{95}$	643	20,000
Cs^{137}	3	2,000
I^{131}	0	670
$Ce^{141}\text{-}Ce^{144}$	3,160	3,300 (Ce^{141})
Sr^{89}	375	3,300
Sr^{90}	3.6	33

Previous coverage in *Radiological Health Data*:

Period	Issue
1961-June 1962	*April 1963*
July-December 1962	*September 1963*
January-June 1963	*March 1964*
July-December 1963	*September 1964*

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2. ICRP Report Number 2.

RADIOACTIVITY IN KENTUCKY WATERS, MAY 1963–JUNE 1964

Radiological Health Program
Kentucky Department of Health

Radioactivity is usually present in all natural surface waters. Prior to 1942, any radioactive minerals in natural waters were there as a result of cosmic radiation and naturally occurring radionuclides in the earth's soil which had been taken up by these surface waters. After that time fallout from nuclear weapons testing and possibly radionuclides in waste water from the atomic industry operations could contribute some additional radioactivity. Sampling of surface waters in the Commonwealth of Kentucky is done for the purpose of establishing the levels of radioactivity presently existing and to establish any relationship between radioactivity levels and stream characteristics.

Surface water samples are collected from 48 sampling locations (figure 1) in seven river basins. General description of the basins in Kentucky can be found in "Surface Water Records of Kentucky" (*1*).

The suspended and dissolved solids in these samples are analyzed for gross alpha and beta radioactivity. Generally, no attempt has been made to determine the specific radionuclides present. Table 1 presents the results of the alpha and beta analyses of the water samples collected from May 1963 through June 1964.

The analytical method used for determining gross alpha and beta radioactivity is similar to that used by the PHS R. A. Taft Sanitary Engineering Center (*2*). One gallon samples are collected and shipped in polyethylene bottles. The volume of water analyzed is selected so that no more than 500 mg of either suspended or dissolved solids is present during counting. Generally, one liter of water is used. The sample is first filtered through a millipore filter Wattman 2/0 to separate the suspended and dissolved solids. The filter is then ashed. The filtrate is evaporated leaving the dissolved solids which are also subsequently dried.

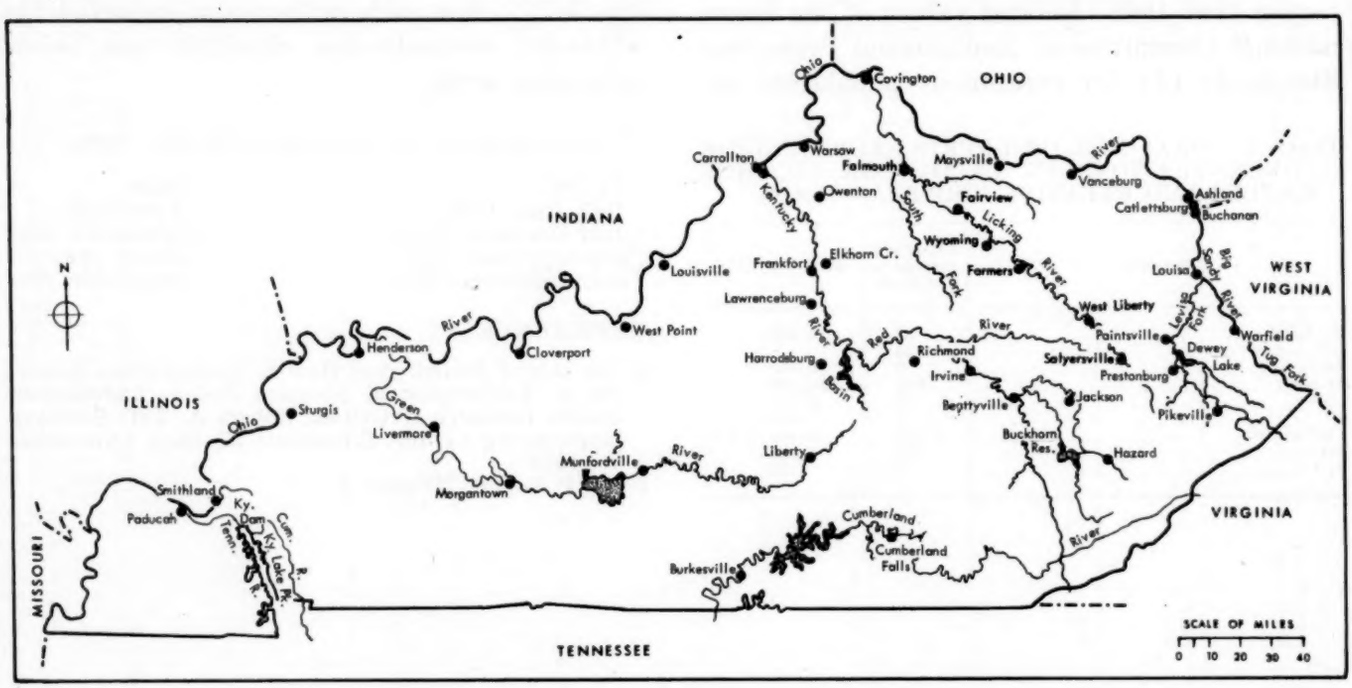

FIGURE 1.—KENTUCKY SURFACE WATER SAMPLING STATIONS

TABLE 1.—AVERAGE GROSS RADIOACTIVITY IN KENTUCKY WATER, MAY 1963–JUNE 1964

[Concentrations in pc/liter]

River basin and location	Dates sampled	Beta			Alpha		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Big Sandy River							
Catlettsburg	6/5/64	6	9	15	<1	<1	<1
Buchanan	6/4/64	29	11	50	<1	<1	<1
Louisa: Louisa Fork	6/4/64	12	10	22	<1	<1	<1
Louisa: Tug Fork	6/4/64	32	9	41	<1	<1	<1
Warfield	6/5/64	4	7	11	<1	<1	<1
Paintsville	6/4/64	16	10	26	<1	<1	<1
Prestonsburg	6/4/64	3	15	18	<1	<1	<1
Dewey Lake	6/4/64	15	8	23	<1	<1	<1
Pikeville	6/4/64	3	7	10	<1	<1	<1
Cumberland River							
Burkesville	6/30/64	9	17	26	<1	<1	<1
Smithland	6/30/64	8	8	16	<1	<1	<1
Cumberland Falls	6/30/64	12	8	20	<1	<1	<1
Green River							
Liberty	5/13/64	2	9	11	<1	<1	<1
Munfordville	5/13/64	13	9	22	<1	<1	<1
Morgantown	5/13/64	7	10	17	<1	<1	<1
Livermore	5/13/64	10	12	22	<1	<1	<1
Henderson	5/13/64	4	15	19	<1	<1	<1
Kentucky River Basin							
Hazard	6/8/64	8	19	27	0	0	0
Jackson	6/8/64	15	20	35	0	<1	<1
Buckhorn Reservoir	6/8/64	7	21	28	<1	<1	<1
South Fork	6/8/64	21	25	46	<1	<1	<1
Beattyville	6/8/64	16	18	33	<1	<1	<1
Irvine	6/8/64	15	12	27	<1	<1	<1
Red River	6/8/64	17	17	34	<1	<1	<1
Richmond	6/8/64	26	13	39	<1	<1	<1
Harrodsburg	6/8/64	34	23	57	<1	0	<1
Lawrenceburg	6/8/64	20	22	42	<1	<1	<1
Frankfort	6/8/64	26	28	54	<1	0	<1
Elkhorn Creek	6/8/64	8	35	43	0	0	0
Owenton	6/8/64	43	25	68	<1	<1	<1
Carrolton	6/8/64	36	23	59	<1	<1	<1
Licking River							
Salyersville	8/18/63	6	12	18	<1	<1	<1
West Liberty	8/18/63	8	15	23	<1	<1	<1
Farmers	8/18/63	3	26	29	<1	<1	<1
Wyoming	8/18/63	5	19	24	<1	<1	<1
Fairview	8/18/63	14	31	45	<1	<1	<1
Falmouth	8/18/63	10	40	50	<1	<1	<1
Ohio River							
Ashland	7/31/63	3	14	17	1	1	2
Vanceburg	7/31/63	3	15	18	2	1	3
Maysville	7/31/63	3	14	17	1	0	1
Covington	7/31/63	3	14	17	1	0	1
Warsaw	7/31/63	3	12	15	0	1	1
Carrollton	7/31/63	3	14	17	2	0	2
Louisville	7/31/63	4	16	20	1	1	2
West Point	7/31/63	4	19	23	1	0	1
Cloverport	7/31/63	8	20	28	1	0	1
Henderson	7/31/63	15	18	33	1	1	2
Sturgis	7/31/63	5	21	26	1	1	2
Tennessee River							
Paducah	7/25/63	7	18	25	0	0	0
Kentucky Lake Park	7/25/63	4	16	20	<1	0	<1
Kentucky Dam	7/25/63	15	20	35	<1	<1	<1

The solid samples are counted for alpha and beta activity in a proportional counter.

Although the few samples collected at irregularly spaced time intervals provide only an indication of base-levels of radioactivity, general levels of gross beta radioactivity have been established for the 48 stations. In addition, some determination of gross alpha concentrations, half-life values, gamma energy spectra, and specific isotope concentrations have been made to establish the probable source of the higher concentrations of gross radioactivity. In specific instances, data on stream flow at the time of collection, and the quantity of suspended and dissolved solids was obtained.

From this initial sampling beginning in May 1963 and continuing through June 1964, the following may be concluded:

Small amounts of radioactivity are present in all sampled surface waters of Kentucky. Varying amounts of gross beta radioactivity were found in samples collected from all major streams during the period May 1963 to June

1964. However, the concentration of radioactivity was well below the maximum permissible concentration limit for continuous exposure to the public as specified in the National Bureau of Standards Handbook 69 (*3*).

Radioactive waste from various industrial, educational, or medical isotope uses are not presently contributing noticeably to radioactivity levels in the streams.

The concentration of suspended radioactivity in surface waters is extremely variable. Suspended beta radioactivity concentrations in water samples collected throughout the State have ranged from less than 2 pc/liter to over 43 pc/liter. The dissolved beta radioactivity content of most streams appears relatively stable as compared to that in the suspended fraction.

Under normal conditions of streamflow the dissolved fraction accounts for essentially all the beta radioactivity. As flow increases the suspended radioactivity content increases for a short period. However, this relationship is not necessarily linear. This would appear to be related to an increase in total suspended solids resulting from increased turbulence.

REFERENCES

1. U. S. Geological Survey. Surface Water Records of Kentucky. U. S. Department of the Interior, District Engineer, Surface Water Branch, U. S. Geological Survey, 522 West Jefferson Street, Louisville 2, Kentucky.
2. Division of Radiological Health. Radionuclide Analyses of Environmental Samples R59–6, Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati 26, Ohio (November 16, 1959).
3. National Bureau of Standards. Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air and in Water for Occupational Exposure. Handbook 69, U. S. Government Printing Office, Washington, D. C. price $0.35.

Section IV—Other Data

RADIUM SOURCE SURVEYS IN KENTUCKY

Radiological Health Program
Kentucky Department of Health

Radium sources constitute a potential radiation hazard because of their ready availability, and because improper handling or storage may lead to loss or rupture (due to internal gas pressure). To protect the health of the citizens of Kentucky from these and other sources of ionizing radiation, regulations were adopted in October 1962 by the Kentucky State Department of Health requiring the registration of naturally-occurring or accelerator-produced radioactive materials and also radiation-producing machines. As a result of the implementation of these regulations, a total of 46 radium users were registered by December 1963. More than 80 percent of the sources registered were in the possession of hospitals or private physicians (see table 1).

TABLE 1.—NUMBERS OF RADIUM USERS

Type of facility	No. of facilities
Hospital	21
Private physician	16
Clinic	4
Academic institution	2
Industrial	2
Veterinarian	1

At the time of source registrations, each user was provided with a copy of the radiation regulations and notified on his registration certificate of the need for annual leak tests of each radium source. They were also provided with a suggested leak-test procedure.

The 46 registered users of radium in the State were surveyed during December 1963 and January 1964. A typical survey provided information regarding owner, type of facility, typical users, and information regarding radiological health procedures practiced at the facility. Results of the Statewide radium survey indicated that concern for radiological health aspects of radium storage and handling was justified (see table 2). The percentages of noncompliance items indicated in table 2, although high, would have been much higher except that State Health Department staff took time to correct many items of noncompliance at the time of the survey.

TABLE 2.—RADIUM SURVEY RESULTS

Items needing correction	Percent of total surveyed
No records of any type of survey performed	52
No type of leak test previously performed	46
Notice to employees not posted	37
Leakage found	35
Radium container not posted (warning signs)	35
Areas not posted (warning signs)	34
Personnel instruction or training not accomplished	22
Radiation surveys of any type not performed	22
Improper storage (unnecessary exposure)	10
No routine operating procedures	9
No records of personnel exposures (film badges, etc.)[1]	4

[1] Regulations require personnel monitoring where an individual is likely to receive in excess of 25 percent of the occupational exposure limit in any calendar quarter.

Discussions with the various users of radium indicated lack of respect for the significance of leaking sources of contamination therefrom. It appeared that most users were

more concerned with the monetary value of the source rather than the potential radiation or contamination problem. Obviously, immediate action was necessary to check for possible leaking sources and contamination, and to provide some guidance and advice concerning proper storage and handling procedures. After this initial information was obtained, a survey kit was prepared consisting of an Eberline PAC–1SA alpha scintillation detector instrument, a Nuclear Chicago Model 2650 instrument with thin-wall and end-window G-M tubes, a box of paper tissue for obtaining smear samples, cotton-tipped sticks and alcohol to clean possibly contaminated detector probe faces, and a calibrated alpha check source of approximately 11,000 dpm (two-pi).

Direct measurements of radiation intensity and that of wipe samples from the sources were made. A wipe sample measuring greater than 200 cpm (with a 2-pi calibrated detector) of alpha activity or its equivalent 0.2 mrad/hr (by end window G-M) of alpha-beta-gamma activity was considered as the "alert level" for further leak testing. It was recommended that these further leak tests be performed on each source by health physics or radiological physics consultants. All collected wipe samples indicating potential contamination were returned to the laboratory and analyzed with internal gas-flow proportional counters to verify results of portable instrument monitoring.

Effectiveness of the survey technique was verified by the consultants finding leaking sources each time radiocontamination was at or above the "alert level." No "leaks" were found in those areas where no radiocontamina-three typical surveys were as indicated in table tion was found above "alert levels." Results of 3.

Test results verified that leaking sources could be readily detected by the use of portable instruments in a program of meticulous surveys of the storage area and storage container, and measurements of wipe-test samples from suspect areas.

Survey report and results forms were prepared not only to assure an orderly and complete recording of data but primarily to provide an immediate report to the user for suggested corrective action. Items of information required on the form were established to assure compliance with the Kentucky Department of Health radiation regulations. At the conclusion of each facility survey, the user was given a result form with the various items of noncompliance indicated and an explanation of what was required to correct the deficiencies. A copy of this form was returned to the Radiological Health Program records after it had been signed by the facility Radiation Safety Officer, or other responsible individual, at the conclusion of the survey discussion.

TABLE 3.—MEASURED CONTAMINATION IN THREE TYPICAL SURVEYS

Sample	Health Department results	Consultant results
	CASE #1	
Smear inside container	500 c/m (alpha)	—
Cotton from 24-hour storage	[a] —	3,000 c/m (alpha)
Cotton from 24-hour storage	—	[b] 0.4 mrad/hr (beta & gamma) with thin-wall G-M.
	CASE #2	
Smear inside container	No contamination	—
Cotton from 24-hour storage	—	No contamination
	CASE #3	
Smear inside container	1,000 c/m (alpha)	—
Direct measurement on lid of container	10,000 c/m (alpha)	—
Cotton from 24-hour storage	—	[c] 100,000 c/m with well-type gamma scintillator.

[a] Dash indicates no measurement done.
[b] The beta and gamma measurement would have been approximately 3 mrad/hr with an end-window G-M detector.
[c] The radioactivity on the sealed cotton from 24-hour closed test tube storage, after the source was removed, decayed with a half-life of approximately 10 hours.

The importance of radiological health surveys of radium users became apparent when a radiation physicist called attention to a leaking radium source that his organization had been given—property from the estate of a deceased physician. The leaking source was properly stored and measurements were made to assure insignificant contamination of equipment and property of the deceased physician. The leaking source and three other radium needles stored in the same container were brought to the Health Department Radiological Laboratory for further study and evaluation of proposed survey techniques and leak test procedures. At the conclusion of these tests, the leaking source was disposed of in an approved manner.

The success of this program was primarily due to the cooperation given survey teams, and interest and corrective action taken by the users in all cases. It is felt that the radium survey, and continuing program of radium source annual surveys, is one of the milestones in the Kentucky Radiological Health Program.

TABLE 4.—PORTABLE INSTRUMENT MEASUREMENTS

Needle No.	Cotton		Smear
	Beta+gamma [1] (mrad/hour)	Alpha+beta [2] (mrad/hour)	Alpha [3] (cpm)
1	[4] BG	BG	BG
2	BG	BG	BG
3	10	300 (off scale)	20,000
4	BG	2.5	150

[1] Determined by Geiger-Mueller detector.
[2] Determined by low-energy ion chamber.
[3] Determined by gas-flow internal proportional counter.
[4] BG indicates reading cannot be distinguished from background.

TABLE 5.—GAMMA SPECTRUM RESULTS

Gamma peak (MEV)	Relative peak activity		
	Needle	Wash water	Cotton
0.10	7.0	7.5	7.0
0.18	5.0	6.0	2.4
0.25	3.8	4.5	3.2
0.30	4.0	3.8	4.1
0.35	4.0	4.0	5.4
0.61	2.3	2.2	3.0
1.0	0.4	0.5	0.4
1.1	0.6	0.6	0.7
1.43	0.5	0.4	0.4
1.75	0.3	0.4	0.4

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors periodic reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity for 23 AEC installations have appeared periodically in *RHD* since November 1960. Following are reports for Argonne National Laboratory, Atomics International, and National Reactor Testing Station.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are essentially identical to those published in the Federal Register (*1*).

1. Argonne National Laboratory, January–June 1964

University of Chicago
Lemont, Illinois

Air monitoring

Weekly continuous samples of airborne particulates for radioactivity measurements at 7 locations on the Argonne National Laboratory (ANL) site as shown in figure 1 and at 5 offsite locations at Aurora (west of ANL site), Wheaton (northwest), Hinsdale (northeast), Joliet (southwest), and Tinley Park (southwest). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 1. The radionuclide determinations were made from gamma spectra of monthly composites of the filters. The data show little difference between offsite and onsite measurements for alpha activity and most of the nuclides, in-

TABLE 1.—RADIOACTIVITY OF AIRBORNE PARTICULATES, ANL, JANUARY–JUNE 1964

[Average concentrations in pc/m³]

Type of analysis	Sampling locations	January	February	March	April	May	June	Average
Alpha	On site	0.0032	0.0036	0.0039	0.0042	0.0051	0.0039	0.0040
	Off-site	0.0029	0.0033	0.0042	0.0042	0.0043	0.0048	0.0040
Beta	On site	0.9	1.0	1.4	1.5	2.0	1.8	1.4
	Off-site	0.9	1.0	1.4	1.5	2.1	2.1	1.5
Sb^{125}	On site	0.02	0.02	0.04	0.05	0.06	0.06	0.04
	Off-site	0.02	0.02	0.04	0.04	0.07	0.06	0.04
Ce^{144}	On site	0.54	0.52	0.63	0.80	1.10	0.85	0.74
	Off-site	0.53	0.48	0.72	0.69	0.99	1.06	0.75
Cs^{137}	On site	0.04	0.04	0.07	0.07	0.11	0.11	0.07
	Off-site	0.04	0.04	0.07	0.08	0.11	0.10	0.07
Ru^{103}	On site	<0.05	<0.05	0.06	0.05	0.06	0.04	0.04
	Off-site	<0.05	<0.05	0.06	0.05	0.08	0.03	0.04
$Ru\text{-}Rh^{106}$	On site	0.24	0.21	0.27	0.28	0.39	0.38	0.30
	Off-site	0.24	0.24	0.28	0.33	0.32	0.43	0.31
$Zr\text{-}Nb^{95}$	On site	0.09	0.07	0.09	0.08	0.09	0.07	0.08
	Off-site	0.08	0.07	0.09	0.08	0.09	0.07	0.08

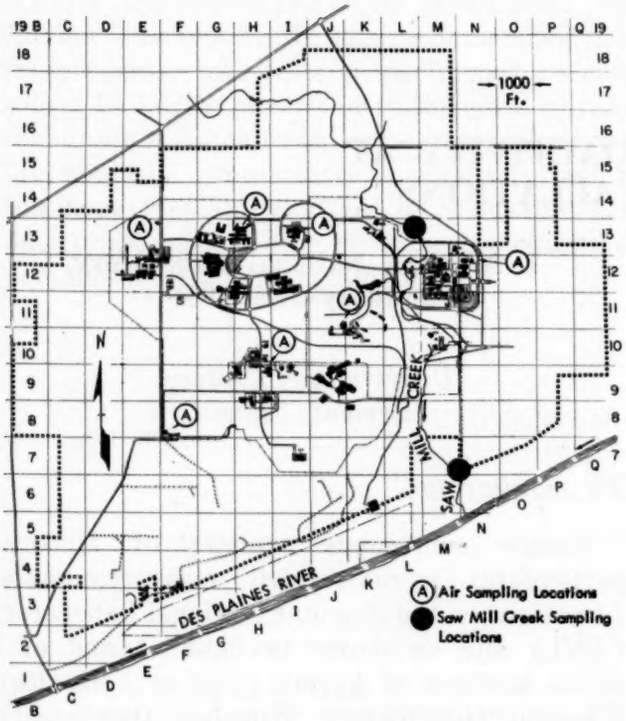

FIGURE 1.—ONSITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

dicating that ANL does not contribute detectable quantities of these activities to the atmosphere. The average airborne beta activity during the first half of 1964 was approximately 1.5 pc/m³.

Water monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne Laboratory site and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2, respectively.

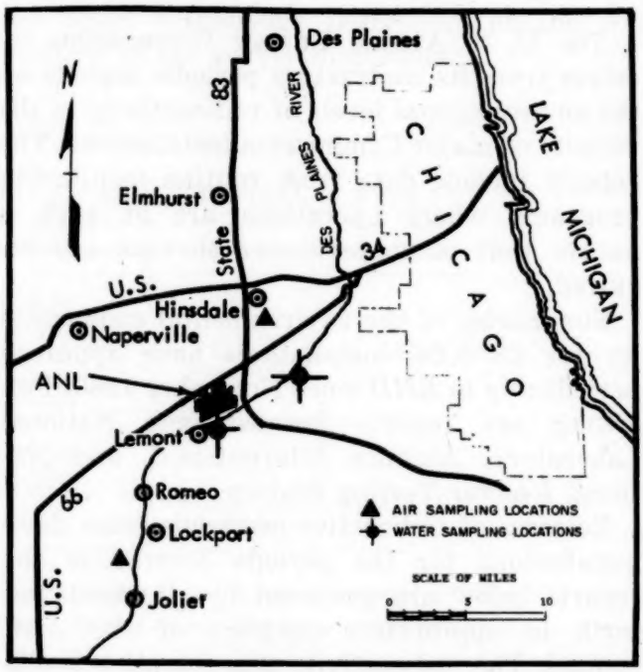

FIGURE 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFFSITE SAMPLING STATIONS)

TABLE 2.—RADIOACTIVITY IN SAWMILL CREEK, ANL, JANUARY–JUNE 1964

[Average concentrations in pc/liter]

Type of analysis	Sampling location	January-June 1964		
		Maximum	Minimum	Average
Alpha emitters:				
Total alpha	Upstream	3.8	0.6	1.5
	Downstream	6.9	1.3	3.7
U-natural	Upstream	2.5	0.3	1.5
	Downstream	8.3	0.9	3.0
Pu^{239}	Upstream	<0.05	<0.05	<0.05
	Downstream	0.35	<0.05	0.10
Th^{232}	Upstream	<0.05	<0.05	<0.05
	Downstream	0.60	<0.05	0.13
Beta emitters:				
Total beta	Upstream	73	7	25
	Downstream	42	13	20
Co^{58}	Upstream	<5	<5	<5
	Downstream	62	<5	5
Co^{60}	Upstream	<3	<3	<3
	Downstream	40	<2	3
Sr^{89}	Upstream	<2	<2	<2
	Downstream	<2	<2	<2
Sr^{90}	Upstream	4.5	<0.5	3.4
	Downstream	5.8	<0.5	1.8
I^{131}	Upstream	<3	<3	<3
	Downstream	<3	<3	<3
Ce^{137}	Upstream	0.8	<0.5	0.4
	Downstream	11.3	<0.5	2.8
Ba^{140}	Upstream	<2	<2	<2
	Downstream	<2	<2	<2
Th-Pa^{234}	Upstream	2.0	0.6	1.2
	Downstream	6.0	0.5	1.9

On Sawmill Creek, weekly grab samples are collected upstream and 3 times a week samples are collected downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow, yielding a dilution factor of one-half. The data in table 2 show higher concentrations downstream and upstream. However, downstream concentrations were well below permissible concentration limits.

Weekly grab samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results indicate that the dilution factor of the Des Plaines River is so large that the radioactivity contribution from ANL is not detectable.

Recent coverage in *Radiological Health Data*:

Period	Issue
Third and fourth quarters 1960	*July 1961*
First and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*May 1962*
1962	*May 1963*
1963	*August 1964*

REFERENCE

1. U.S. Atomic Energy Commission. Rules and regulations, standards for protection against radiation. Federal Register. Title 10, Part 20, Appendix B, Table 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

2. Atomics International January–June 1964

Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops, and constructs nuclear reactors for control stations, compact power plants, and medical, industrial, and scientific applications. Locations of the facilities are shown in figure 3.

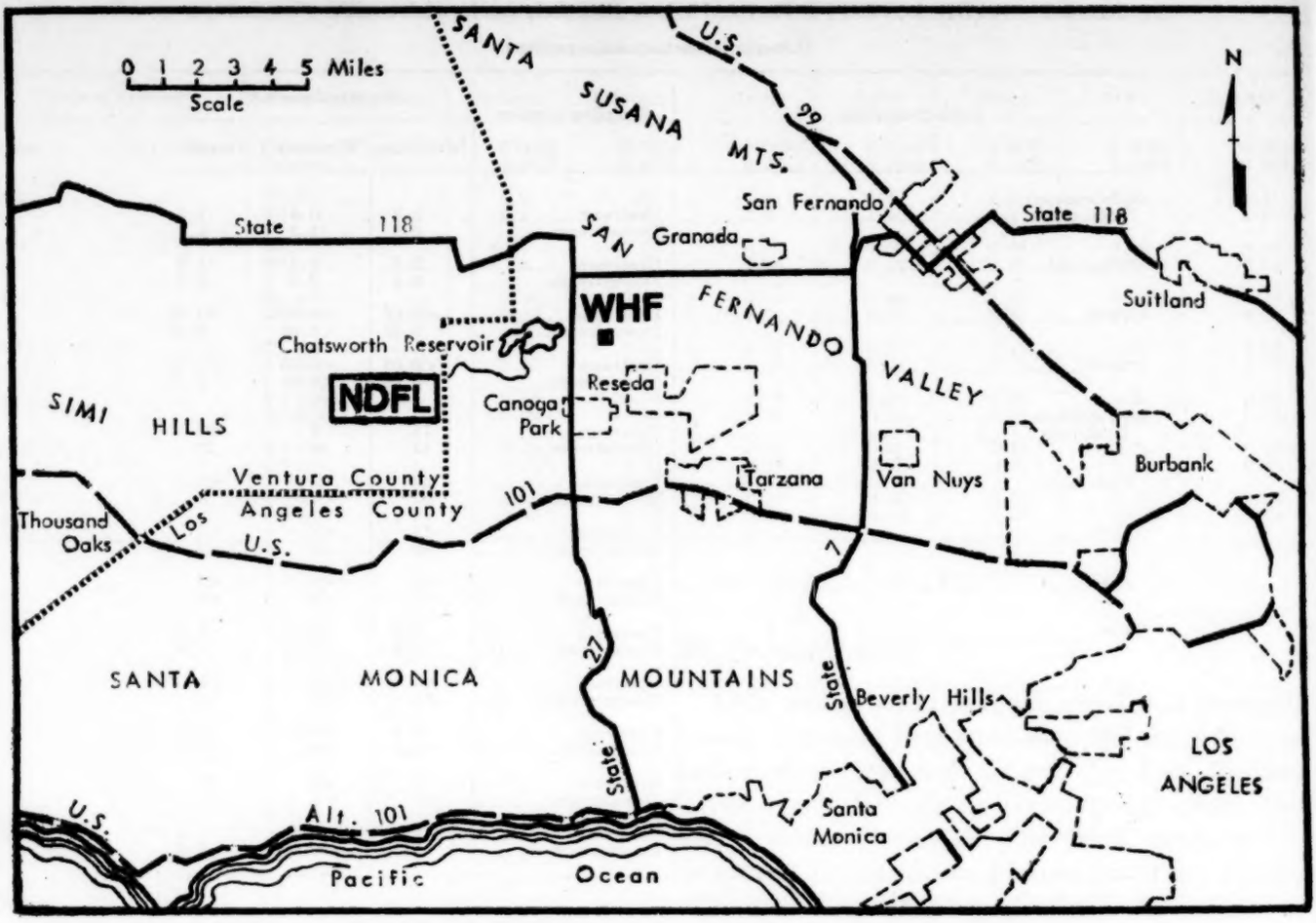

FIGURE 3.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor; several smaller experimental reactor facilities such as critical facilities, Systems for Nuclear Auxiliary Power (SNAP) reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building, but a small amount of fuel fabrication is conducted there. For this reason, the WHF area is included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design. Surface soil, vegetation, water and air samples are surveyed periodically.

Air monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours, and counted in an automatic proportional counting system. The volume of atypical daily air sample is approximately 21 cubic meters. Averages for beta-gamma activity in airborne particulates are given in table 3.

Water samples

Processed water at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Monthly samples are collected from these wells (see table 4). Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one-liter polyethylene bottles for transfer to the laboratory. Water samples from the lake surface and supply inlet of Chatsworth

TABLE 3.—AIRBORNE PARTICULATE RADIOACTIVITY DATA

[activity in pc/m³]

Site	1963		First half 1964	
	Number of samples	Average concentration	Number of samples	Average concentration
Headquarters	360	6.6	182	2.0
NDFL	292	4.7	69	1.9

TABLE 4.—WELL WATER MONITORING, NDFL

[pc/liter]

Activity	1963		First half 1964	
	Number of samples	Average	Number of samples	Average
α	24	*0.18	11	*0.12
β, γ	24	7.0	11	*4.7

* Rounded from range of values originally reported.

Reservoir are similarly obtained (see table 5). In some cases the average concentration is presented as a range. The range occurs when one or more of the samples analyzed contains an undetectable amount of radioactivity.

TABLE 5.—CHATSWORTH RESERVOIR WATER SAMPLING

[pc/liter]

Sample	Activity	1963		First half 1964	
		Number of samples	Average	Number of samples	Average
Lake surface	α	37	0.84	12	0.60
	β, γ	37	18	12	12.6
Supply inlet	α	12	*0.58	6	*0.41
	β, γ	12	*9.1	6	10.

* Rounded from range of values originally reported.

In the laboratory, 500 ml. of water are evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred into stainless steel planchets, wetted to produce an even sample distribution, redried under infra-red lamps, and counted in an automatic proportional counting system.

Soil and vegetation samples

Soil and vegetation are sampled monthly at 51 locations. Thirteen sampling stations are located within the boundaries of Atomics International and are designated as on site stations. The remaining 38 stations are located within a 10-mile radius of Atomics International and are referred to as off-site stations. Several of the off-site stations are located at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power.

Surface soil samples range from decomposed granite to clay and loam and are collected from the top half-inch layer of ground surface. The samples are placed in plastic containers and sent to the laboratory. Sample preparation consists of ashing in a muffle furnace at 500°C. for approximately eight hours, cooling, and sieving to obtain uniform particles for counting. One-gram aliquots of the soil are put in stainless steel planchets, wetted with acetone, redried, and counted in an automatic proportional counting system. Alpha and beta-gamma activities of soil samples are given in table 6.

TABLE 6.—SOIL RADIOACTIVITY

[pc/g]

Area	Activity	1963		First half 1964	
		Number of samples	Average	Number of samples	Average
On-site	α	156	*0.42	74	*0.35
	β-γ	156	45	74	35
Off-site	α	455	*0.40	221	*0.32
	β-γ	455	42	221	33

* Rounded from range of values originally reported.

Vegetation samples obtained in the field at each station are generally sunflower or wild tobacco plant leaves. At the laboratory the leaves are stripped from the plant and washed to remove foreign matter. The vegetation, after a distilled water rinse, is ashed in a muffle furnace at 500°C. for approximately eight hours, producing a completely oxidized ash of uniform density. Three-hundred milligram aliquots of ground ash are used for counting in an automatic proportional counting system. Vegetation data are shown in table 7.

TABLE 7.—RADIOACTIVITY IN VEGETATION

[pc/gm ash]

Area	Activity	1963		First half 1964	
		Number of samples	Average	Number of samples	Average
On-site	α	156	*0.44	76	*0.39
	β-γ	156	465	76	247
Off-site	α	456	*0.37	227	*0.39
	β-γ	456	388	227	231

* Rounded from range of values originally reported.

Previous coverage in *Radiological Health Data*:

Period	Issue
1960 and First and Second quarters 1961	*December 1961*
Third and Fourth quarters 1961	*August 1962*
Calendar Year 1962	*November 1963*
Calendar Year 1963	*September 1964*

3. National Reactor Testing Station January–June 1964

Health and Safety Division
Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located about 20 miles from Idaho Falls, Idaho, in a very remote area which in a large measure permits controlled releases of radioactivity from the projects with minimum risk to the environs.

Responsibility for holding the environmental radioactivity levels at the station below the Radiation Protection Guides (RPG) recommended by the Federal Radiation Council (FRC) lies with the Atomic Energy Commission. One of the safeguards employed is a monitoring program. Descriptions of the monitoring network procedures have been presented earlier (see previous coverage). Beginning in January 1964, air data was reported by a radiation telemitry system while the former dual filter system continued in operation to obtain comparative data. The new system includes data from ion chambers and results of G-M counts from filter paper tapes. Quarterly environmental monitoring results in addition to averages for January to June 1964, are shown in table 8. Sampling locations at NRTS can be seen in figure 4.

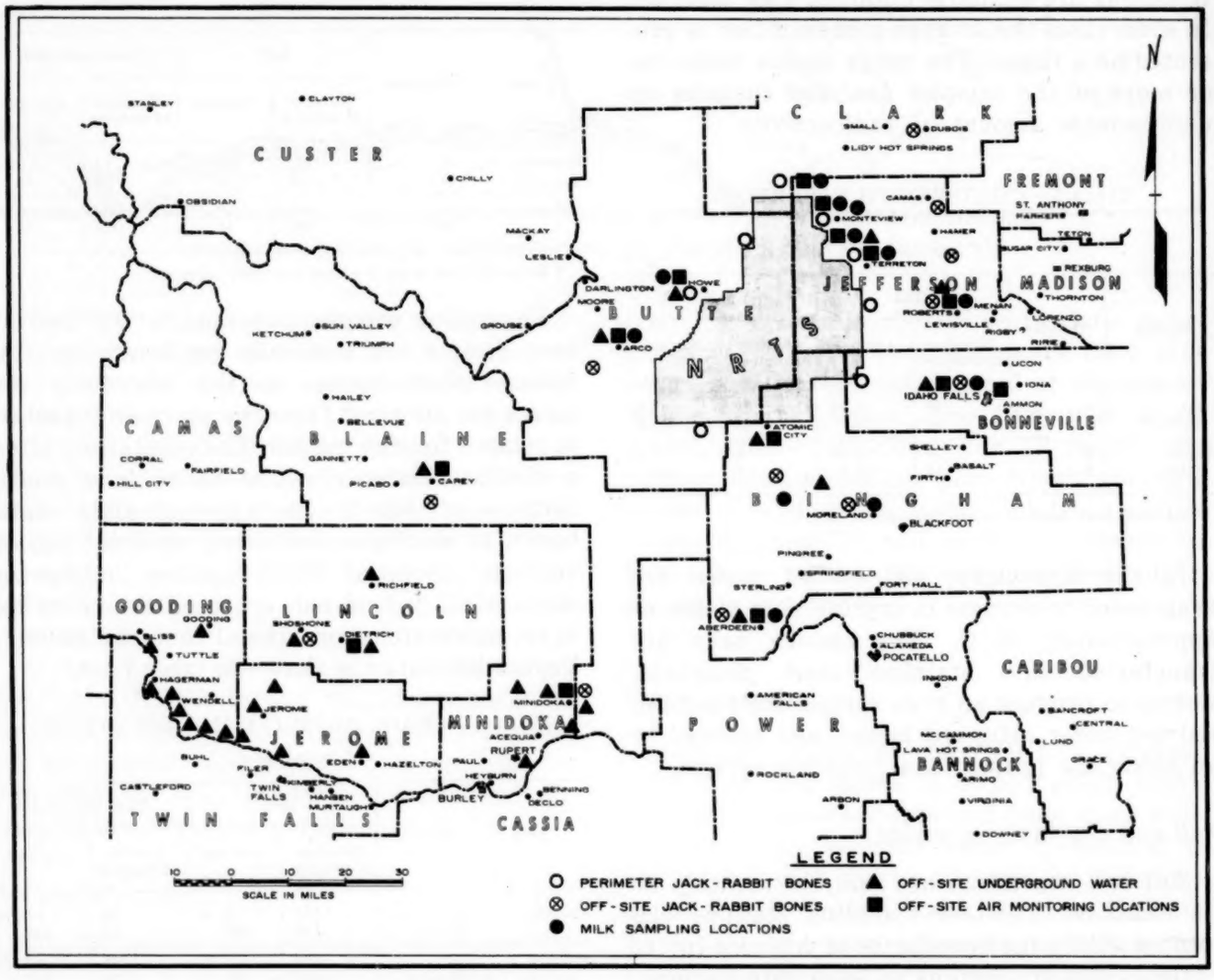

FIGURE 4.—ENVIRONMENTAL MONITORING STATIONS

TABLE 8.—ENVIRONMENTAL MONITORING PROGRAM DATA, NRTS, JANUARY–JUNE 1964

Type of sample and units	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample
Off-site underground water (pc/liter)	32	semi-annual	alpha	3	9	<4
			beta	6	20	<10
On-site production well water (pc/liter)	22	two weeks	alpha	3	7	<4
			beta	6	100	<20
Off-site air (pc/m³)	15	continuous	beta-gamma	1.6	19	<1.6
	15		iodine-131	3.6	40	<3.6
Off-site milk (pc/liter)	14	monthly	iodine-131	20	<20	<20
	11	monthly	strontium-90	1.5	44	28
Off-site area monitoring badges (mrem)	14	monthly	beta	10	10	<60
			gamma	10	25	<60

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first quarter 1960	*November 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*May 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*June 1962*
1962	*June 1963*
1963	*September 1964*

REPORTED NUCLEAR DETONATIONS, FEBRUARY 1965

During the month of February three United States nuclear tests were announced by the Atomic Energy Commission.

The February 4, 16, and 18 tests were conducted underground at the Nevada Test Site. All were of low-yield (less than 20 kilotons).